BUILDING INFORMATION MODELLING (BIM) PERFORMANCE EVALUATION MODEL IN THE MALAYSIAN CONSTRUCTION INDUSTRY

ROLYSELRA ORBINTANG ANAK ROBIN

A thesis submitted in fulfillment of the requirement for the award of the
Doctor of Philosophy in Technology Management

Faculty of Technology Management and Business
Universiti Tun Hussein Onn Malaysia

MAY 2023

ACKNOWLEDGEMENTS

In the name of Allah, Most Gracious, Most Merciful.

Alhamdulillah, with His Blessings, I have finally completed this thesis.

Firstly, I would like to thank my supervisor Dr Mohd Yamani bin Yahya for his advice and guidance to complete this thesis confidently. Thanks for your patience and faith in me!

Secondly, I would like to express my sincere thanks to my parents, Robin Neo and Selina Nyala, for their prayers and patience to make this endeavour successful. My special gratitude is due to my loved one Hafiz and my brothers (Benmara, Jansbyn, Augustyne, Jhansyne). Thank you for showering me with love, concern, and support.

Special thanks to my study mates who supported and comforted me: Nur Asyikin Mohd Sairi and Misriyanti Saikah. Not forgetting my English Teacher, Larry Lim - I appreciate your support and encouragement.

I would like to gratefully acknowledge my deep appreciation to the Malaysian Ministry of Highest Education and Centre of Graduate Studies, UTHM, for the financial support and opportunity to complete my study.

Finally, I would like to thank all of the respondents of this research, who gave their insights and valuable time freely in helping me throughout my study. My apologies to those people unfairly omitted in this acknowledgement.

ABSTRACT

Building Information Modelling (BIM) has received greater attention from Malaysian construction industry players since it was introduced in 2007. Although significant support from the government to enhance BIM implementation, the implementation of BIM in private and public construction sectors is still poor. BIM CIDB Report 2016-2019 identified the lack of direction of BIM implementation cause as a challenge in delaying the Malaysian construction industry's target to achieve Level 2. Preliminary interviews with two BIM experts in Malaysia found that the government and CIDB tend to achieve the target by continuously monitoring and evaluating BIM implementation. However, there are limited studies on BIM performance in the Malaysian construction industry. Most BIM implementation studies were based only on the benefits, challenges, awareness and readiness of BIM. There are remaining uncertainties regarding the actual performance of the organisations that implement BIM due to the lack of evaluation models that can evaluate BIM performance in Malaysia. Therefore, this study aims to develop a performance model for BIM implementation in the Malaysian construction industry. This study employed a qualitative study consisting of two data collection phases. Semi-structured and structured interview (using the AHP technique) sessions were conducted with BIM experts around Peninsular Malaysia during the data collection period. Semi-structured interview findings identified five main metrics and twenty-nine sub-metrics of BIM performance metrics. In addition, the structured interviews (AHP) findings have categorised the BIM performance metrics based on importance level. The value of consensus also exceeds 50%, which confirms that the agreement on the value of metric weights among the experts is acceptable. The validation results showed that BIM experts agreed that the developed BIM performance model was suitable and acceptable for the Malaysian construction industry. In conclusion, the proposed and developed BIM performance model would benefit practitioners, especially the PWD and CIDB, to evaluate the performance of BIM organisations in the Malaysian construction industry.

ABSTRAK

Building Information Modelling (BIM) telah mendapat banyak perhatian daripada pemain industri pembinaan Malaysia sejak ia diperkenalkan pada 2007. Walaupun sokongan besar daripada kerajaan untuk meningkatkan pelaksanaan BIM, pelaksanaan BIM dalam sektor pembinaan swasta dan awam masih lemah. Laporan BIM CIDB 2016-2019 mengenalpasti kekurangan hala tuju punca pelaksanaan BIM sebagai cabaran dalam melambatkan sasaran industri pembinaan Malaysia untuk mencapai Tahap 2. Temu bual awal bersama dua pakar BIM di Malaysia mendapati kerajaan dan CIDB cenderung untuk mencapai sasaran dengan memantau dan menilai pelaksanaan BIM secara berterusan. Walau bagaimanapun, kajian mengenai prestasi BIM dalam industri pembinaan Malaysia sangat terhad. Kebanyakan kajian pelaksanaan BIM hanya berdasarkan kepada faedah, cabaran, kesedaran dan kesediaan BIM. Masih terdapat ketidakpastian berhubung prestasi sebenar organisasi yang melaksanakan BIM kerana kekurangan model penilaian yang boleh menilai prestasi BIM di Malaysia. Oleh itu, kajian ini bertujuan untuk membangunkan model prestasi pelaksanaan BIM dalam industri pembinaan Malaysia. Kajian ini menggunakan kajian kualitatif yang terdiri daripada dua fasa pengumpulan data. Sesi temu bual separa berstruktur dan berstruktur (menggunakan teknik AHP) telah dijalankan bersama pakar-pakar BIM di sekitar Semenanjung Malaysia. Penemuan temu bual separa berstruktur mengenalpasti lima metrik utama dan dua puluh sembilan sub-metrik metrik prestasi BIM. Selain itu, dapatan temu bual berstruktur (AHP) telah mengkategorikan metrik prestasi BIM berdasarkan tahap kepentingan. Nilai *consensus* juga melebihi 50%, yang mengesahkan bahawa persetujuan mengenai nilai pemberat metrik di kalangan pakar boleh diterima. Keputusan pengesahan menunjukkan bahawa pakar BIM bersetuju bahawa model prestasi BIM yang dibangunkan adalah sesuai dan boleh diterima untuk industri pembinaan Malaysia. Kesimpulannya, model prestasi BIM yang dicadangkan dan dibangunkan akan memberi manfaat kepada pengamal, terutamanya JKR dan CIDB, untuk menilai prestasi organisasi BIM dalam industri pembinaan Malaysia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEC	-	Architecture, Engineering and Construction
AHP	-	Analytical Hierarchy Process
BIM	-	Building Information Modelling
CIDB	-	Construction Industry Development Board
CDE	-	Common Data Environment
CREAM	-	Construction Research Institute of Malaysia
EIR		Employer's Information Requirements
IFC	-	Industry Foundation Classes
LOD	-	Level of Development
Lod	-	Level of Detail
LOI	-	Level of Information
MCDM	-	Multi-Criteria Decision Making
PWD	-	Public Works Department

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

In the construction field, the implementation of BIM is increasing worldwide, which allows the construction industry's evolution to be significantly influenced. Implementing BIM is considered vital as it has a wide range of benefits in construction projects, which helps to expand productivity across the stakeholders (Roger *et al*., 2015). BIM was first introduced to the Malaysian construction industry in 2007 by the Public Works Department (PWD) (Latiffi *et al*., 2013). Since then, Malaysian construction industry has been trying to enhance their construction performance through the introduction of BIM (Othman *et al*., 2020). The studies conducted by Zahrizan *et al*. (2013) and Enegbuma *et al*. (2014) stated that the BIM implementation level in the Malaysian construction industry is still low.

To enhance BIM implementation in Malaysia, the Ministry of Works (KKR) and its agency, the Construction Industry Development Board (CIDB) Malaysia, have worked together to boost the construction industry's productivity in Malaysia. BIM is highlighted as one of the technologies under Productivity Thrust in the Construction Industry Transformation Programme (CITP) 2016–2020; BIM acts as a platform to allow various stakeholders to collaborate in the planning, design, and construction of buildings using 3D models (CIDB, 2016). The CITP showed there are several KPIs

that have been listed under the Technology Focus Area. For example, to implement BIM at least 40% of Level 2 in 2020 for 100% of public building projects above RM 100 million (for JKR building projects) and 70% of private and public building projects above RM 10 million will adopt BIM by Jan 2021 (CIDB, 2019). Hence, the CIDB and its subsidiaries have made efforts to promote BIM by carrying out various BIM-related programs such as BIM Day, BIM Road tours, incentives, seminars, workshops, and others to empower the usage of BIM in the Malaysian construction industry. MyBIM (2020) reported that the Malaysian Ministry, through the Strategic Plan 2021-2025 of the Public Works Department (PWD), has scheduled the mechanism's implementation to hit 50 % by 2021 and 80 % by 2025.

Although significant support from the government to enhance BIM implementation, the implementation of BIM in private and public construction sectors is still poor (Hasni *et al*., 2019; Othman *et al*., 2021). BIM CIDB Report 2016-2019 identified the lack of direction of BIM implementation cause as a challenge in delaying the Malaysian construction industry's target to achieve Level 2. Hence, the government and CIDB tend to achieve the target by continuous monitoring and evaluation of BIM implementation. To measure the effectiveness of BIM implementation, an in-depth understanding of current BIM performance in an organisation is vital. It can enable the government and CIDB to improve future strategies supporting BIM implementation in the Malaysian construction industry.

The majority of the BIM implementation studies were only based on the benefits, challenges, awareness and readiness of BIM (Arif *et al*. (2021); Othman *et al*. (2021); Al-Ashmori *et al*. (2020); Kong *et al*. (2020); Roslan *et al*. (2019); Musa *et al*. (2018). However, there is a minimal study on BIM performance undertaken by the Malaysian construction industry due to the lack of knowledge in BIM performance evaluation. Malaysian BIM practitioners have difficulties understanding their BIM performance. Therefore, this study recommended that the BIM performance evaluation increase the BIM implementation level in Malaysia. The BIM performance should be evaluated rather than only promoting the advantages and the implementation benefits. It is essential to develop a BIM performance model to ensure that the best practice of BIM in Malaysia may be identified and expanded. Organisations can better understand what they can do or should change to improve their ability to perform in BIM implementation (Succar, 2013). As the management literature states, if you cannot measure something, then you cannot control, manage, and improve it (Garvin,

1993; Martin *et al*., 2009). Therefore, this study identified the critical components of BIM performance evaluation. In addition, the study also proposed a model as a fundamental to evaluate BIM performance in the Malaysian construction industry.

1.2 Research Problem

This study identified 13 BIM performance models that were developed to evaluate BIM performance around the world (McCuen & Suermann, 2007; Bew & Richard, 2008; Indiana University, 2009; Succar, 2009; Sebastian & Van Berlo, 2010; CPIc, 2011; Kam *et al*., 2013; Strategic Building Innovation, 2013; CICRP, 2013; Du *et al*., 2014; Giel & Issa, 2013; Liang *et al*., 2016; Yilmaz *et al*., 2019). Even though there are several existing models from other countries have been developed to evaluate BIM performance, there are no standard forms (models) of BIM performance evaluation in Malaysia. The models cannot be adopted in Malaysia due to various technologies, expertise and the different levels of BIM implementation (Mansson *et al*., 2016; Al-Ashmori *et al*., 2019). An expanded BIM performance model for the Malaysian construction industry can be developed based on the models' essential components of the models; BIM performance evaluation scope, performance metrics and performance level classification. Yilmaz *et al*. (2019) summarised that the essential components of developing a BIM performance model are the scope and purpose, selection and classification of metrics, overall score, and performance levels. According to Succar (2013), BIM performance can be evaluated based on individual, organisation, and project performance. As a result of the preliminary interview with the BIM experts in the Malaysian construction industry, this study focused on developing a model to evaluate BIM performance in an organisation. Evaluating individual and project performance was challenging, given that a limited project used the BIM process from pre-construction until post-construction. Most of the projects employed the BIM process solely during the design stage. Additionally, there is limited skilled individual in the Malaysian construction industry.

After deciding the BIM performance evaluation scope, it is essential to identify relevant metrics based on the Malaysian construction industry context. However, there is a lack of appropriate metrics to evaluate BIM performance due to limited studies on

BIM performance in Malaysia (Hasan Z., personal communication, February 25, 2018). The problem implied that Malaysia's organisation could not achieve level 2 of BIM implementation because they could not track the critical metrics that led them to success. The BIM performance metrics are critical in learning about the organisation's internal system and resource capability. Liang *et al*. (2016) suggest including three main metrics (process, policy and technology) and twenty-one sub-metrics in developing a multifunctional BIM performance model. Yilmaz (2017) encouraged an organisation to evaluate BIM performance based on five main metrics; people, process, organisation, policy, and technology. This study starts by exploring and identifying the issues in Malaysia to create effective performance metrics for BIM evaluation. The preliminary interviews showed five metrics to evaluate BIM performance: Organisation, Process, Policy, Technology, and People. Since BIM performance is still new in the Malaysian construction industry, this study expanded and identified BIM performance metrics based on the findings of the preliminary interview. In addition, the development of BIM performance metrics should be adapted to various organisations, especially Architecture, Engineering, and Construction (AEC). A good performance metric is designed to monitor the different types of organisation and whether it is on track to achieve their goals (Eckerson, 2010).

Once the performance metrics for the evaluation are selected, the performance metrics need weightage to prioritise which metric is essential and greatly impacts the BIM implementation (Hamid M.F., personal communication, November 9, 2018). The accuracy of the evaluation depends on the 'weight' applied to the performance metrics. A problem in the performance evaluation process is that the evaluation participant may score very much on the less critical performance metrics and poorly on essential metrics. This problem signifies that each performance metric should have a different value depending on its relative importance in the BIM implementation. It is the process of 'weighting' selection performance metrics to reflect their relative value. Unfortunately, most weighting decisions tend to be a matter of guesswork, which ultimately detracts from the accuracy of the evaluation. According to Zardari *et al.* (2015), Multi-Criteria Decision Making (MCDM) may be the best solution to provide decision-makers with a tool to enable them to weigh the criteria. The AHP method is a well-known MCDM technique for applying weighting systems in various scopes. It is an efficient technique for determining the weighting structure for construction appraisal programs in various nations (Chang *et al*., 2007; Ali & Al Nsairat, 2009;

Londoño-Pineda *et al*., 2021). In the case of BIM, studies have been carried out using AHP as a tool to obtain a weighting system (Cao & Zheng, 2014; Chen & Li, 2015; Liang *et al*., 2019). Since the BIM performance evaluation is new to the BIM practitioners in Malaysia, it is essential to derive the metrics weights from the top-level BIM practitioner's judgment on the metric. The subjective judgement method is to determine weights solely according to the preferences of BIM practitioners (level of knowledge and experience in BIM). This study proposed a subjective judgment method called the Analytical Hierarchy Process (AHP) technique to assign the weight of each BIM performance metric for the Malaysian construction industry. The AHP technique is the appropriate mathematical method for prioritising and quantifying verbal judgement based on the decision maker's experiences and intuitions into numbers (De Felice *et al.,* 2015).

1.3 Research Question

i. What metrics are used to evaluate the organisation's BIM performance in the Malaysian construction industry?
ii. How to assign BIM performance metrics weightage for the organisation in the Malaysian construction industry?
iii. How to develop a BIM performance model for the organisation in the Malaysian construction industry?
iv. How to validate the BIM performance model for the organisation in the Malaysian construction industry?

1.4 Research Objectives

i. To identify the metrics for evaluating the organisation's BIM performance in the Malaysian construction industry.
ii. To assign importance weightings for each BIM performance metrics in the Malaysian construction industry.

iii. To develop a BIM performance model for the organisation in the Malaysian construction industry.
iv. To validate the BIM performance model for the organisation in the Malaysian construction industry.

1.5 Research Significance

This study would lead to a broader and in-depth understanding of Building Information Modelling (BIM) performance for the organisation in the Malaysian construction industry. It discusses the significance of the BIM performance model to academia and industry.

1.5.1 Significance to Academia

This study will unveil why the Malaysian construction industry cannot evaluate BIM performance. Hence, this study will further add to the literature by identifying the components of developing a BIM performance model. In addition, this study identified the metrics used to evaluate BIM performance, which would contribute to academia by developing the model for the Malaysian construction industry.

1.5.2 Significance to the Construction Industry

This study could assist Malaysian BIM organisations in understanding how the evaluation could increase the organisation's ability to perform in BIM. This study can offer a clear picture of how a BIM organisation in the construction industry could perform the performance evaluation. This study aims to develop a performance model to improve the BIM implementation in the construction industry. Notably, developing

a model is vital as it could be used as a reference and grounded to evaluate BIM performance in the Malaysian construction industry. The information established from the research findings could benefit the BIM organisations in evaluating their performance. With the application of this model, BIM organisation in the Malaysian construction industry could increase their competitiveness and fulfil the organisation's mission and vision.

1.6 Research Scope

The research scope and respondents for the study will revolve around BIM implementation in the Malaysian construction industry, specifically Peninsular Malaysia. According to CIDB (2019), many implementors are located in the central region, consisting of five states: Kuala Lumpur, Putrajaya, Selangor, Malacca, and Negeri Sembilan. This result is contributed to the rapid development and large-scale BIM projects in this region compared to East Malaysia.

The respondent of the study is restricted to top-level management in an organisation. The selection of the respondents was based on purposive sampling with predetermined criteria, such as the respondents' position in the organisation and years of BIM experience. The respondents in this study were targeted to be from the public and private sectors, including clients/developers, consultants, and contractors. CIDB (2019) stated that clients/developers are the top BIM implementors in Malaysia, followed by consultants (Architects, Engineers, Quantity Surveyors) and Contractors. The respondents are selected because they have the power to be involved in BIM implementation in the whole construction stages (pre-construction, construction, post-construction).

The second criteria are that the respondents must be experienced in BIM implementation for more than three years. Respondents with more than three years of experience will provide more details and information about the BIM implementation. The percentage of BIM practitioners with working experience of 0-5 years in Malaysia improved in three years (CIDB, 2019).

In addition, the BIM roles in the organisation are also included in selecting the respondents. The most important roles are BIM Manager, the BIM Coordinator and

the BIM Modeler (Borrman *et al*., 2018). The roles were categorised as BIM experts who had specific knowledge and responsibilities. Each contributes to the BIM process with their know-how, skills and competencies on processes, technologies, team members, and standards/procedures.

This study employed a qualitative study as a research method. The qualitative study was applied to collect data for this study, mainly through two phases of interviews; semi-structured and structured interviews (AHP technique).

1.7 Research Methodology

This section highlights the method adopted to achieve the research objectives. The research methodology consists of five main stages. The next sections illustrate the adopted research methods, followed by Chapter 3 that thoroughly illustrates the selected research methods and the justification for the selection.

Stage 1: Identification of Research Area

The study area was identified by collecting information on BIM in the Malaysian construction industry through a literature review and preliminary interviews. The literature review was based on academic and industry literature, which included books, refereed journals, conference proceedings, and online searches on the websites within the research area. The literature review also assisted in formulating the research questions and objectives, structuring the research design and methodology, and selecting the research instruments for a more efficient data collection and analysis. In addition, preliminary interviews were conducted with two BIM experts in Malaysia to explore the current BIM issues in the Malaysian construction industry. At the end of the stage, a conceptual model was developed based on the literature review and preliminary interview findings. The conceptual model included five main metrics and twenty-nine sub-metrics of the BIM performance metrics.

Stage 2: Objective 1 (Semi-structured Interview)

Stage 2 adopted a qualitative study (semi-structured interview) to achieve the study's first objective. The objective of the semi-structured interviews was to identify and establish the BIM performance metrics for the organisation in the Malaysian construction industry. A set of open-ended interview questions were developed based on the literature review and preliminary interviews. The study used purposive sampling to select the respondents who fit the study's criteria. There are three main criteria for the respondent selection for the study; the type of organisation, the respondent's position in the organisation and years of BIM experience. Before conducting the interview, the study contacted the respondents by WhatsApp to verify the classification of the respondent's background; then emailed the letter of consent (Appendix E) to inform the respondent about the study area and to seek their permission for the interview session. Stage 2 findings identified five main metrics and twenty-nine sub-metrics of the BIM performance metrics relevant to the Malaysian construction industry. Besides, the findings were also used to develop variables for AHP survey questions in the next stage (Stage 3)

Stage 3: Objective 2 (Structured Interview – AHP)

Stage 3 also adopted a qualitative study to achieve Objective 2. This stage performed structured interviews to assign weightage to the BIM performance metrics. The closed-ended questions (AHP survey) were developed based on the findings from the semi-structured interview. This stage also employed purposive sampling to select respondents. Following that, the findings from Stage 3 contributed to the modification of the conceptual model.

Stage 4: Objective 3 (Model Development)

Stage 4 included the development of the BIM performance evaluation model based on the literature review, preliminary interview, semi-structured interview and structured interview findings. The BIM performance model was developed for the organisation in the Malaysian construction industry.

REFERENCES

Abudayyeh, O., Zidan, S. J., Yehia, S., & Randolph, D. (2007). Hybrid prequalification-based, innovative contracting model using AHP. *Journal of Management in Engineering. 23(2)*, pp. 88-96.

AEC UK Initiative (2012). AEC (UK) BIM Protocol; Implementing UK BIM Standards for the Architectural. Engineering and Construction Industry. The AEC (UK) BIM Protocol v2. 0. UK.

Akadiri, P. O., Olomolaiye, P. O., & Chinyio, E. A. (2013). Multi-criteria evaluation model for the selection of sustainable materials for building projects. *Automation in construction. 30*, pp. 113-125.

Al-Ashmori, Y. Y., Othman, I. B., Mohamad, H. B., Rahmawati, Y., & Napiah, M. (2019). Establishing the level of BIM implementation–a case study in Melaka, Malaysia. In *IOP Conference Series: Materials Science and Engineering*. *601(1)*, pp. 012024. IOP Publishing.

Al-Ashmori, Y. Y., Othman, I., Rahmawati, Y., Amran, Y. M., Sabah, S. A., Rafindadi, A. D. U., & Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia. *Ain Shams Engineering Journal*. *11*(4), pp. 1013-1019.

Ali, H. H. and Al Nsairat, S. F. (2009). Developing a green building assessment tool for developing countries–Case of Jordan. *Building and Environment. 44(5)*. pp. 1053-1064.

Alonso, J. A., & Lamata, M. T. (2006). Consistency in the analytic hierarchy process: a new approach. *International journal of uncertainty, fuzziness and knowledge-based systems*. *14*(04), pp. 445-459.

Aminbakhsh, S., Gunduz, M., & Sonmez, R. (2013). Safety risk assessment using analytic hierarchy process (AHP) during planning and budgeting of construction projects. *Journal of safety research*. *46*, pp. 99-105.

American Institute of Architects. (2008). AIA Document E202 Building Information Modeling Protocol Exhibit.

Amponsah, C. T. (2010). *Public-private partnerships: Critical success factors for procurements of capital projects*. Capella University: Ph.D. Thesis.

Arayici, Y., Egbu, C. O., & Coates, S. P. (2012). Building information modelling (BIM) implementation and remote construction projects: issues, challenges,

and critiques. *Journal of Information Technology in Construction*. 17, pp. 75-92.

Arif, N. K., Hasmori, M. F., Deraman, R., Yasin, M. N., & Yassin, M. M. (2021). Readiness of Malaysian Small and Medium Enterprises Construction Companies for Building Information Modelling Implementation. In *IOP Conference Series: Materials Science and Engineering*. *1200 (1)*, pp. 012027. IOP Publishing.

Azhar, S., Nadeem, A., Mok, J. Y., & Leung, B. H. (2008). Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects. In *Proc., First International Conference on Construction in Developing Countries*. *1*, pp. 435-46.

Azhar S. (2011). Building information modeling (BIM): trends, benefits, risks and challenges for the AEC industry, *Journal of Leadership and Management in Engineering*. 11 (3), pp. 241–252.

Azhar, S., Khalfan, M., & Maqsood, T. (2012). Building information modeling (BIM): now and beyond. *Australasian Journal of Construction Economics and Building. The*, *12*(4), pp. 15-28.

Aziz, N. F., Sorooshian, S., & Mahmud, F. (2016). MCDM-AHP method in decision makings. *ARPN Journal of Engineering and Applied Sciences. 11(11)*, pp. 7217-7220.

Batagarawa, R., Williams, J. B., Potts, J. S., & Brown, J. C. (2015). Use of analytic hierarchy process (AHP) as an instrument to develop a solid waste management assessment tool. *Global Journal of Advanced Engineering Technologies*. *4(2)*, pp. 70.

Becerik-Gerber, B., & Rice, S. (2010). The perceived value of building information modeling in the US building industry. *Journal of Information Technology in Construction (ITcon)*. *15(15)*, pp. 185-201.

Bercerik-Gerber, B., Jazizadeh, F., Li, N., & Calis, G. (2012). Application areas of data requirements for BIM-enabled facility management. *Journal of Construction Engineering and Management*. *138*(3), pp. 431-442.

Bew, M. (2008). Bew-Richards BIM maturity model. In BuildingSMART Construct IT Autumn Members Meeting. Brighton.

Bhole, G. P., & Deshmukh, T. (2018). Multi-criteria decision making (MCDM) methods and its applications. *International Journal for Research in Applied Science & Engineering Technology (IJRASET), 6(5)*, 899-915.

Borrmann, A., König, M., Koch, C., & Beetz, J. (2018). *Building information modeling: Why? what? how? (pp. 1-24)*. Springer International Publishing.

Brinkmann, S. (2014). *Unstructured and semi-structured interviewing*. *The Oxford handbook of qualitative research*, 2, 277-299. USA: Oxford University Press.

Brückner, I., MAßLING, N., Wozniak, M., & Thieme-Hack, M. (2019). How to develop a BIM-Workflow for landscape architecture: A practical approach. *Journal of Digital Landscape Architecture*, 4-2019.

Bryman, A. (2012). *Social research methods (5th ed.)*. New York: Oxford University Press.

Building and Construction Authority (2013). Singapore BIM Guide Version 2.

Business Performance Management Singapore (BPMSG) (2011). Concepts, Methods and Tools to Manage Business Performance.

Cao, J. W., & Zheng, H. K. (2014). Study on cost decision model based on BIM and AHP. In *Applied Mechanics and Materials*. 584, pp. 2205-2208. Trans Tech Publications Ltd.

Chang, K. F., Chiang, C. M., & Chou, P. C. (2007). Adapting aspects of GBTool 2005—searching for suitability in Taiwan. *Building and Environment*. *42*(1), pp. 310-316.

Chen, Y., Dib, H., & Cox, R. F. (2014). A measurement model of building information modelling maturity. *Construction Innovation*. 14 (2), pp. 186-209.

Chen, K., & Li, H. (2015). AHP Based Weighting System for BIM Implementation and Assessment Framework. *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*. pp. 1727-1731.

Cheng, E. W., & Li, H. (2002). Construction partnering process and associated critical success factors: quantitative investigation. *Journal of management in engineering*. 18(4), pp. 194-202.

Chien, K. F., Wu, Z. H., & Huang, S. C. (2014). Identifying and assessing critical risk factors for BIM projects: Empirical study. *Automation in Construction*, 45, 1-15.

Chou, J. S., Pham, A. D., & Wang, H. (2013). Bidding strategy to support decision-making by integrating fuzzy AHP and regression-based simulation. *Automation in Construction*. *35*, pp. 517-527.

Cole, R. J. (2005). Building environmental assessment methods: redefining intentions and roles. *Building Research & Information*. *33*(5), 455-467.

Computer Integrated Construction Research Program (CICRP)(2013). BIM Planning Guide for Facility Owners. Pennsylvania State University: University Park, PA.

Construction Industry Development Board (CIDB) (2015). BIM Guide 5: BIM Project Guide. Malaysia: myBIM Malaysia.

Construction Industry Development Board (CIDB) (2016). *BIM Guide Malaysia*. Malaysia: myBIM Malaysia.

Construction Industry Development Board (CIDB) (2019). *2019 Annual Report: Driving Construction Industry Transformation.*

Construction Project Information Committee (CPIc) (2011). CPIx-BIM Assessment Form.

Construction Research Institute of Malaysia (CREAM) (2014). Issues and challenges in implementing building information modelling (BIM) for SME's in the construction industry. Kuala Lumpur, Malaysia: Construction Research Institute of Malaysia (CREAM).

Costa, D. B., Formoso, C. T., Kagioglou, M., Alarcón, L. F., & Caldas, C. H. (2006). Benchmarking initiatives in the construction industry: lessons learned and improvement opportunities. *Journal of Management in Engineering*. 22(4), pp. 158-167.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches.* 2nd edition. Thousand Oaks, CA: Sage.

Dalal, J., Mohapatra, P. K., & Mitra, G. C. (2010). Prioritization of rural roads: AHP in group decision. *Engineering, Construction and Architectural Management*.

Dahan, E., & Hauser, J. R. (2002). The virtual customer. *Journal of Product Innovation Management: An International Publication of the Product Development & Management Association*. 19(5), pp. 332-353.

Dahan, E., Soukhoroukova, A., & Spann, M. (2010). New product development 2.0: Preference markets—How scalable securities markets identify winning

product concepts and attributes. *Journal of product innovation management*. 27(7), pp. 937-954.

Darko, A., Chan, A. P. C., Ameyaw, E. E., Owusu, E. K., Pärn, E., & Edwards, D. J. (2019). Review of Application of Analytic Hierarchy Process (AHP) in Construction. *International Journal of Construction Management*. 19(5), pp. 436-452.

Das, S., Chew, M. Y. L., & Poh, K. L. (2010). Multi-criteria decision analysis in building maintainability using analytical hierarchy process. *Construction Management and Economics*. *28*(10), 1043-1056.

Davies, K., McMeel, D., & Wilkinson, S. (2015). Soft skill requirements in a BIM project team. J. Beetz, T. Hartmann, L. van Berlo, R. Amor (Ed.), *Proceedings of the 32nd International Conference of CIB W78*, pp.108-117.

De Felice, F., Deldoost, M. H., & Faizollahi, M. (2015). Performance measurement model for the supplier selection based on AHP. *International Journal of Engineering Business Management*. 7, pp. 7-17.

Ding, L., Zhou, Y., & Akinci, B. (2014). Building Information Modeling (BIM) application framework: The process of expanding from 3D to computable nD. *Automation in construction*. *46*, pp. 82-93.

Doloi, H. (2008). Application of AHP in improving construction productivity from a management perspective. *Construction Management and Economics*. 26(8), pp. 841-854.

Du, J., Liu, R., & Issa, R. R. (2014). BIM cloud score: benchmarking BIM performance. *Journal of Construction Engineering and Management*. 140(11), pp. 04014054.

East, E. W. (2007). *Construction Operations Building Information Exchange (COBie).* Engineer Research and Development Center. Construction Engineering Research Laboratory. ERDC/CERL TR-07-30. Final Report.

Eastman, C. M., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. John Wiley & Sons.

Eckerson, W. W. (2010). *Performance dashboards: measuring, monitoring, and managing your business.* John Wiley & Sons.

El-Sayegh, S. M. (2009). Multi-criteria decision support model for selecting the appropriate construction management at risk firm. *Construction Management and Economics*. 27(4), pp. 385-398.

Enegbuma, W. I., Aliagha, U. G., & Ali, K. N. (2014). Preliminary building information modelling adoption model in Malaysia: A strategic information technology perspective. *Construction Innovation, 14 (4),* pp 408-432.

Forman E. H. & Gass S. I. (2001). The Analytic Hierarchy Process—An Exposition. *Operations Research. 49(4)*, 469-486.

Furneaux C & Kivit R (2008). BIM: Implications for Government CRC for Construction Innovation Case Study No. 5 [2004-032-A + Case study no. 5]. Australia: *Cooperative Research Centre for Construction Innovation*. pp. 10-31.

Garvin, D. A. (1993). Building a learning organisation. *Harvard Business Review. 71(4)*. pp. 78-91.

Giel, B., & Issa, R. R. (2013). Synthesis of Existing BIM Maturity Toolsets to Evaluate Building Owners. *Computing in Civil Engineering*. pp 451-458.

Goepel, K. D. (2013). Implementing the Analytic Hierarchy Process as A Standard Method for Multi-Criteria Decision Making in Corporate Enterprises–A New AHP Excel Template with Multiple Inputs. *Proceedings of The International Symposium on the Analytic Hierarchy Process. 2 (10)*, pp. 1-10. Creative Decisions Foundation Kuala Lumpur.

Goepel, K. D. (2019). Comparison of judgment scales of the analytical hierarchy process—A new approach. *International Journal of Information Technology & Decision Making, 18(02)*, 445-463.

Golden, B. L., Wasil, E. A., & Harker, P. T. (1989). The analytic hierarchy process. *Applications and Studies, Berlin, Heidelberg, 2(1)*, 1-273.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Sage.

Guba, E. G. (1990). *The Paradigm Dialog. In Alternative Paradigms Conference, Indiana U, School of Education, San Francisco, Ca*. US. Sage Publications, Inc.

Hair, J. F., Money, A. H., Samouel, P., & Page, M. (2007). Research methods for business. *Education+ Training*, *49(4)*, 336-337.

Hardin, B. (2009). *BIM and Construction Management: proven Tools, Methods, and Workflow*. Indiana: Wiley Publishing Inc.

Hasni, M. I. A. K., Ismail, Z., & Hashim, N. (2019). Contractual aspects in the utilisation of level two building information modelling (BIM) within Malaysian public construction projects. In *MATEC Web of Conferences*. 266, pp. 05002. EDP Sciences.

Honti, R., & Erdélyi, J. (2018). Possibilities of BIM data exchange. *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management (SGEM). 18(2.2)*, pp. 923-930.

Hyun, C., Cho, K., Koo, K., Hong, T., & Moon, H. (2008). Effect of delivery methods on design performance in multifamily housing projects. *Journal of Construction Engineering and Management. 134(7)*, pp. 468-482.

Indiana University (IU) (2009). *Building information modeling (BIM) guidelines and standards for architects, engineers, and contractors*. Indiana University: University Architect's Office.

Kam, C., Senaratna, D., McKinney, B., Xiao, Y., & Song, M. (2013). *The VDC scorecard: Formulation and validation*. Center for Integrated Facility Engineering: Stanford University.

Kamaruzzaman, S. N., Lou, E. C. W., Wong, P. F., Wood, R., & Che-Ani, A. I. (2018). Developing weighting system for refurbishment building assessment scheme in Malaysia through analytic hierarchy process (AHP) approach. *Energy Policy*, *112*, pp. 280-290.

Khalil, N., Kamaruzzaman, S. N., & Baharum, M. R. (2016). Ranking the indicators of building performance and the users' risk via Analytical Hierarchy Process (AHP): Case of Malaysia. *Ecological indicators*, 71, pp. 567-576.

Koh, J. H. L., Chai, C. S., Hong, H. Y., & Tsai, C. C. (2015). A survey to examine teachers' perceptions of design dispositions, lesson design practices, and their relationships with technological pedagogical content knowledge (TPACK). *Asia-Pacific Journal of Teacher Education*. 43(5), pp. 378-391.

Kong, S. W. R., Lau, L. T., Wong, S. Y., & Phan, D. T. (2020). A study on effectiveness of Building Information Modelling (BIM) on the Malaysian construction industry. In *IOP Conference Series: Materials Science and Engineering*. 713 (1), pp. 012035. IOP Publishing.

Kubba, S. (2012). *Handbook of green building design and construction: LEED, BREEAM, and Green Globes*. Butterworth-Heinemann.

Kymmell, W. (2008). *Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations*. United State: McGraw-Hill Education.

Laakso, M., & Kiviniemi, A. O. (2012). The IFC standard: A review of history, development, and standardization, information technology. *ITcon*, *17*(9), pp. 134-161.

Lam, K. C., Lam, M. C. K., & Wang, D. (2008). MBNQA-oriented self-assessment quality management system for contractors: fuzzy AHP approach. *Construction Management and Economics*. 26(5), pp. 447-461.

Latiffi, A. A., Mohd, S., Kasim, N., & Fathi, M. S. (2013). Building information modeling (BIM) application in Malaysian construction industry. *International Journal of Construction Engineering and Management*. *2*(4A), pp. 1-6.

Latiffi, A. A., Brahim, J., & Fathi, M. S. (2014). The development of building information modeling (BIM) definition. *In Applied mechanics and materials*. Vol. 567, pp. 625-630.

Latiffi, A. A., Brahim, J., & Fathi, M. S. (2016). Transformation of Malaysian construction industry with building information modelling (BIM). In *MATEC Web of Conferences* (Vol. 66, p. 00022). EDP Sciences.

Lee, W. L., Chau, C. K., Yik, F. W. H., Burnett, J., & Tse, M. S. (2002). On the study of the credit-weighting scale in a building environmental assessment scheme. *Building and Environment*. *37*(12), 1385-1396.

Lee, G., Sacks, R., & Eastman, C. M. (2006). Specifying parametric building object behavior (BOB) for a building information modeling system. *Automation in construction*. *15*(6), pp. 758-776.

Lee, S., Yu, J., & Jeong, D. (2015). BIM acceptance model in construction organisations. *Journal of Management in Engineering*, 31(3), 04014048.

Li J., & Zou P. X. (2011). Fuzzy AHP-based risk assessment methodology for PPP projects. *Journal of Construction Engineering and Management*. 137(12), pp. 1205-1209.

Liang, C., Lu, W., Rowlinson, S., & Zhang, X. (2016). Development of a multifunctional BIM maturity model. *Journal of construction engineering and management*. 142(11), pp. 06016003.

Liang, S. M., Wu, I. C., Zhuang, Z. Y., & Chen, C. W. (2019). Analytic Hierarchy Process as a Tool to Explore the Success Factors of BIM Deployment in

Construction Firms. In ISARC. *Proceedings of the International Symposium on Automation and Robotics in Construction*. 36, pp. 897-905. IAARC Publications.

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Thousand Oaks, CA: Sage.

Londoño-Pineda, A., Cano, J. A., & Gómez-Montoya, R. (2021). Application of ahp for the weighting of sustainable development indicators at the subnational level. *Economies*. *9*(4), pp. 169.

Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in educational research*, 16(2), 193-205.

Månsson, D., Lindahl, G., Sanchez, A., Hampson, K. D., & Vaux, S. (2016). BIM performance and capability. *Delivering Value with BIM: A Whole-of-life Approach. London: Routledge*. pp. 46-57.

Martin, J. D., Petty, J. W., & Wallace, J. S. (2009). *Value Based Management with Corporate Social Responsibility*. USA: Oxford University Press.

Mays, N. & Pope, C. (1995). Rigour and qualitative research. *British Medical J*ournal, *311*, pp. 109–112.

McCuen, T., & Suermann, P. (2007). The Interactive Capability Maturity Model and 2007 AIA TAP BIM Award Winners. AECbytes Viewpoint, 33(6).

McGraw Hill Construction (2014). The business value of BIM for construction in major global markets: How contractors around the world are driving innovation with building information modeling. Smart MarketReport, 1-60.

Meng, Y., Li, X., & Ma, C. (2014). Application of the Fuzzy Comprehensive Evaluation Based on AHP in the BIM Application Maturity Evaluation. In *ICCREM 2014: Smart Construction and Management in the Context of New Technology*. pp. 280-286.

Messner, J., & Kreider, R. (2013). *BIM planning guide for facility owners*. USA: Pennsylvania State University.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

Mom, M., Tsai, M. H., & Hsieh, S. H. (2011). On decision-making and technology-implementing factors for BIM adoption. In *International Conference on Construction Applications of Virtual Reality*. pp. 86-92.

Musa, S., Marshall-Ponting, A., Shahron, S. A., & Abdul Nifa, F. (2019). Building information modeling (BIM) benefits and challenges: Malaysian construction

organisation experience. *Journal of Computational and Theoretical Nanoscience*. *16*(12), pp. 4914-4924.

MyBIM (2020). Govt Aims 80% Adoption of BIM System by 2025, MyBIM Malaysia, https://mybim.cidb.gov.my

Nam, S. N., Nguyen, T. T., & Oh, J. (2019). Performance indicators framework for assessment of a sanitary sewer system using the analytic hierarchy process (AHP). *Sustainability*. *11*(10), pp. 2746.

National Institute of Building Sciences (NIBS) (2007). National Building Information Modeling Standard Version 1-part 1: Overview, Principles and Methodologies.

National Institute of Building Sciences (NIBS) (2015). National BIM Standard-United States Version 3. In *Section 4.2: Construction Operation Building Information Exchange (COBie),* Version 2.4, pp. 1-252. Washington DC: National Institute of Building Sciences.

Offenbeek, M A G and Vos, J F J (2016) An integrative framework for managing project issues across stakeholder groups. *International Journal of Project Management, 34(1)*, 44-57.

Othman, I., Al-Ashmori, Y. Y., Rahmawati, Y., Amran, Y. M., & Al-Bared, M. A. M. (2021). The level of building information modelling (BIM) implementation in Malaysia. *Ain Shams Engineering Journal*. *12*(1). pp. 455-463.

Ozorhon, B., & Cinar, E. (2015). Critical success factors of enterprise resource planning implementation in construction: Case of Turkey. *Journal of Management in Engineering*, 31(6), 04015014.

Ozorhon, B., & Karahan, U. (2017). Critical success factors of building information modeling implementation. *Journal of management in engineering, 33(3)*, 04016054.

Pan, N. F. (2008). Fuzzy AHP approach for selecting the suitable bridge construction method. *Automation in construction. 17(8),* pp. 958-965.

Pan, W., Dainty, A. R., & Gibb, A. G. (2012). Establishing and weighting decision criteria for building system selection in housing construction. *Journal of Construction Engineering and Management. 138(11)*, pp. 1239-1250.

Penttilä, H. (2006). Describing the changes in architectural information technology to understand design complexity and free-form architectural expression. *Journal of Information Technology in Construction (ITcon)*. *11*(29), pp. 395-408.

Quigley, D. E. (2013). *Achieving Spatial Coordination through BIM. A Guide for Specialty Contractors*. pp. 20-36.

Ramanathan, R. (2001). A note on the use of the analytic hierarchy process for environmental impact assessment. *Journal of environmental management*. *63*(1), pp. 27-35.

Rogers, J., Chong, H. Y., & Preece, C. (2015). Adoption of Building Information Modelling technology (BIM): Perspectives from Malaysian engineering consulting services firms. *Engineering, Construction and Architectural Management*, *22*(4), 424-445.

Roslan, A. F., Hamid, Z. A., Zain, M. Z. M., Kilau, N. M., Dzulkalnine, N., & Hussain, A. H. (2019). Building information modelling (BIM) stage 2 implementation strategy for the construction industry in Malaysia. *Malaysian Construction Research Journal*. *6*, pp. 153-161.

Saaty, T.L. (1980) *The Analytic Hierarchy Process*. New York: McGraw-Hill.

Saaty, T. L. (1982). The analytic hierarchy process: A new approach to deal with fuzziness in architecture. *Architectural Science Review*. *25*(3), pp. 64-69.

Saaty, T. L. (1994). How to make a decision: the analytic hierarchy process. *Interfaces*. *24*(6), pp. 19-43.

Saaty, T. L. (2000). *Fundamentals of Decision Making and Priority Theory with The Analytic Hierarchy Process*. Pittsburg: RWS Publications.

Sanchez, A., Hampson, K., & Vaux, S. (2016). *Delivering value with BIM*. Oxon: Routledge. pp. 105-194.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Sayer, A. (1999). *Realism and social science*. US. Sage.

Scandura, A. (2016). University–industry collaboration and firms' R&D effort. *Research Policy*. *45*(9), pp. 1907-1922.

Sebastian, R., & van Berlo, L. (2010). Tool for benchmarking BIM performance of design, engineering and construction firms in the Netherlands. *Architectural engineering and design management*. 6(4), pp. 254-263.

Shahin, A., & Mahbod, M. A. (2007). Prioritization of key performance indicators: An integration of analytical hierarchy process and goal setting. *International Journal of Productivity and Performance Management*.

Shapira, A., & Goldenberg, M. (2005). AHP-based equipment selection model for construction projects. *Journal of construction engineering and management*. *131*(12), pp. 1263-1273.

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research, 3(7)*, 749-752.

Singapore Building Construction Authority (2013). Singapore BIM guide—version 2. Singapore: Building and Construction Authority Singapore.

Smith, D. K., & Tardif, M. (2009). *Building information modeling: a strategic implementation guide for architects, engineers, constructors, and real estate asset managers*. John Wiley & Sons.

Sriyolja, Z., Harwin, N., & Yahya, K. (2021). Barriers to Implement Building Information Modeling (BIM) in Construction Industry: A Critical Review. In *IOP Conference Series: Earth and Environmental Science*, Vol. 738, No. 1, p. 012021). IOP Publishing.

Strategic Building Innovation (2013). bimSCORE. https://sbi.international

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in construction*. *18*(3), pp. 357-375.

Succar, B., Sher, W., & Williams, A. (2012). Measuring BIM performance: Five metrics. *Architectural Engineering and Design Management*. *8*(2). pp. 120-142.

Succar, B., Sher, W., & Williams, A. (2013). An integrated approach to BIM competency assessment, acquisition and application. *Automation in construction*. *35*, pp. 174-189.

Succar (2013). BIM Performance & Measurement Improvement (Presentation Slides). Seminar and Workshop at the University of Malaya. Academia. https://www.academia.edu/3529511/BIM_Performance_Measurement_and_Improvement_presentation_slides_

Succar, B., & Sher, W. (2014). A competency knowledge-base for BIM learning. *Australasian Journal of Construction Economics and Building-Conference Series. 2(2)*, pp. 1-10.

Takim, R. (2005). *A framework for successful construction project performance.* Glasgow Caledonian University: Ph.D. Thesis.

Tavares, R. M., Tavares, J. L., & Parry-Jones, S. L. (2008). The use of a mathematical multicriteria decision-making model for selecting the fire origin room. *Building and Environment*. *43(12)*, pp. 2090-2100.

Toubia, O., & Florès, L. (2007). Adaptive idea screening using consumers. *Marketing Science*. *26(3)*, pp. 342-360.

Travaglini, A, Radujkovic, M and Mancini, M (2014) Building Information Modelling (BIM) and project management: A stakeholder's perspective. *Organisation, Technology and Management in Construction, 6(2)*, 1058-1065.

Villena-Manzanares, F., García-Segura, T., & Pellicer, E. (2020). Organisational factors that drive to BIM effectiveness: technological learning, collaborative culture, and senior management support. *Applied Sciences, 11(1)*, 199.

Weygant R. S. (2011). *BIM Content Development: Standards, Strategies, and Best Practices*. John Wiley & Sons.

Wong, A.K.D., Wong, F.K.W. & Nadeem (2009). A. Government Roles in Implementing Building Information Modelling Systems. *Construction Innovation*. 1(1), 61-76.

Wu, C., Xu, B., Mao, C., & Li, X. (2017). Overview of BIM maturity measurement tools. *Journal of Information Technology in Construction (ITcon)*. *22*(3), pp. 34-62.

Yang, H. H., & Lin, Y. C. (2018). Developing the Standard Operating Procedures of BIM Collaboration Management for General Contractor. [Unpublished manuscript].

Yılmaz, G. (2017). BIM-CAREM: *A reference model for building information modelling capability assessment*. Middle East Technical University: Ph.D. Thesis.

Yilmaz, G., Akcamete, A., & Demirors, O. (2019). A Reference Model for BIM Capability Assessments. *Automation in Construction*. 101, pp. 245-263.

Yu, P. L. (2013). *Multiple-criteria decision making: concepts, techniques, and extensions Vol. 30*. New York: Springer.

Zahrizan, Z., Ali, N. M., Haron, A. T., Marshall-Ponting, A., & Hamid, Z. A. (2013). Exploring the adoption of Building Information Modelling (BIM) in the Malaysian construction industry: A qualitative approach. *International Journal of Research in Engineering and Technology*. *2*(8), pp. 384-395.

Zardari, N. H., Ahmed, K., Shirazi, S. M., & Yusop, Z. B. (2015). *Weighting methods and their effects on multi-criteria decision making model outcomes in water resources management*. Springer Cham.

Zhang, G., & Zou, P. X. (2007). Fuzzy Analytical Hierarchy Process Risk Assessment Approach for Joint Venture Construction Projects in China. *Journal of Construction Engineering and Management*. 133(10), pp. 771-779.

Zou, P. X., & Li, J. (2010). Risk identification and assessment in subway projects: case study of Nanjing Subway Line 2. *Construction Management and Economics*. 28(12), pp. 1219-1238.

VITA

The author was born on July 7, 1991, in Sibu, Sarawak. She got her early education at Methodist Chinese Kindergarten, Sibu. Later, she went to SJK (C) Sacred Heart Chinese, Sibu and SK Methodist Anglo-Chinese, Sarikei, for her primary school. She continued her studies at the secondary school level at Sekolah Menengah Kebangsaan (SMK) Meradong from 2004 until 2008. After obtaining the Sijil Pelajaran Malaysia (SPM), the author continued her studies in the lower and upper six grades at the same school from 2009 until 2010. In 2015 and 2017, Ms Rolyselra completed her studies for a Bachelor's Degree in Technology Management (Construction) with honours and a Master's Degree of Science in Construction Technology Management at Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat. In 2017, the author registered at the same university as a doctoral student. This author's writing has been done under the supervision of Ts. Dr Mohd Yamani Bin Yahya as a condition for awarding a Doctor of Philosophy in Technology Management. This writing is the author's third writing.