

THE STATE OF READINESS OF THE INTERIOR DESIGN INDUSTRY IN THE
ADOPTION OF BUILDING INFORMATION MODELLING IN MALAYSIA

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Faculty of Built Environment and Surveying
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APRIL 2020

DEDICATION

This thesis is dedicated to beloved wife, who taught me that the best kind of knowledge to have is that which is learned for its own sake and always give a moral supported. Not forget to my kids who understand the tasks and the times that have to be sacrificed during this study. It is also dedicated to my mother and father, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In preparing this thesis, I would like to express my deepest thanks to my supervisor Associate Professor Dr. Mohamed Rashid Embi, Department of Architecture, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia (UTM) for providing me outstanding guidance, encouragement and valuable advice to finish my thesis. I have benefited greatly from his directions, clarify of thought, vast experience in administration and research and his capacity to provide feedback on ideas and on my drafts of chapters. I am very grateful for his patience, motivation, enthusiasm, and immense knowledge. Without his continued support and interest, this thesis would not have been the same as presented here.

Special thanks to my mother, Mrs. Nor bte Abdullah and my father, Mr. Abd. Hamid bin Kasran for valuable advice and always reminding me to focus my research and study whenever I am facing the problems and pressure while preparing this thesis by giving some motivation and spirit to support me.

My gratitude is also towards all the interviewees and respondents, their supports and help are not only crucial to make the research successful but also valuable in enriching my learning process during the investigation and interview process.

I would also like to give my special thanks to my family especially my wife, Mrs Norashikin bte Rahmat, do not forget to my beloved kids, for their all support during the years I have been working on this thesis. Thank you for believing in me and always being there in my ups and downs.

ABSTRACT

Building Information Modelling (BIM) is a radically emerging technology approach for design, construction and facility management that is capable of facilitating building design and construction more efficiently. This work aims to assess the effectiveness of BIM implementation for interior design firms by looking at the opportunities and barriers involved. Is it practical for BIM to deal with implementation problems and improve work overall process efficiency? Or can it improve design knowledge and technology in interior design firms? The implementation of BIM in the interior design industry remains behind, as compared to other building professions. Preliminary studies demonstrate that lack of knowledge about BIM is among the reasons as to why interior design firms do not implement BIM technology. Hence, there is a vital need to identify why BIM technology is not implemented by interior design firms. The purpose of this work is to identify methods to improve the implementation of BIM in the interior design industry. The primary objective is to develop a conceptual framework for the implementation of BIM technology in the interior design firm. The methodology involves applying descriptive survey methods such as structured questionnaires and interviews for selected interior design firms. The study was conducted at 63 interior design firms located around the Klang Valley in Malaysia, which were selected by using three groups, namely, small, medium and large. Two methods of data were collected, namely, quantitative data (questionnaire) and qualitative data (interview). Data from the questionnaire was used to determine potential factors and barriers to BIM implementation, while the interview data describes in detail the questionnaire data. The findings reveal that the knowledge and costs implementation are the primary barriers as to why the interior design firms do not implement BIM. Additionally, technology and human resources are also barriers that are faced when implementing BIM in interior design firms. The study also found that large interior design firms do not face many barriers in the implementation of BIM, while small interior design firms face problems in the application of BIM. Subsequently, on the basis of quantitative and qualitative data, a conceptual framework was developed to increase the application of BIM in interior design firms. This framework was discussed and verified with interior design experts, and is intended to act as a guideline for the interior design industry in increasing the implementation of BIM. This study is crucial, as research on the implementation of BIM in the interior design industry is still lacking, and needs to be improved by reducing the identified barrier factors.

ABSTRAK

Pemodelan Maklumat Bangunan (BIM) merupakan teknologi baharu yang muncul secara radikal untuk reka bentuk, pembinaan dan pengurusan kemudahan. BIM berupaya memudahkan proses reka bentuk bangunan dan pembinaan bangunan dengan lebih cekap. Tesis ini akan menilai keberkesanan penggunaan dan pelaksanaan BIM di firma reka bentuk dalaman dari segi peluang serta halangannya. Adakah penggunaan BIM dapat menangani masalah pelaksanaan dan meningkatkan kecekapan proses kerja? Atau adakah BIM dapat meningkatkan pengetahuan dan teknologi reka bentuk di firma reka bentuk dalaman? Tidak dinafikan, pelaksanaan BIM dalam industri reka bentuk dalaman sangat jauh ketinggalan berbanding industri pembinaan lain. Kajian awal menunjukkan kekurangan pengetahuan mengenai BIM adalah salah satu punca mengapa firma reka bentuk dalaman tidak menggunakan teknologi BIM. Oleh itu, terdapat keperluan untuk mengetahui dengan lebih lanjut punca teknologi BIM tidak dilaksanakan dalam amalan firma reka bentuk dalaman. Tujuan tesis ini adalah untuk mengenal pasti kaedah meningkatkan pelaksanaan dan penggunaan BIM dalam industri reka bentuk dalaman. Objektif utama kajian adalah untuk membangunkan kerangka konseptual pelaksanaan teknologi BIM di firma reka bentuk dalaman dengan mengambil kira hasil penemuan kajian dan juga kajian literatur. Kaedah tinjauan deskriptif digunakan dalam kajian ini, iaitu soal selidik berstruktur dan temu bual di beberapa firma reka bentuk dalaman terpilih. Kajian telah dijalankan di enam puluh tiga (63) firma reka bentuk dalaman yang berada di sekitar Lembah Klang, Malaysia. Sampel kajian dipilih melalui tiga (3) kumpulan: firma kecil, sederhana dan besar. Dua bentuk data telah dikumpul iaitu data kuantitatif (soal selidik) dan kualitatif (temubual). Data bagi soal selidik telah digunakan untuk mencari faktor-faktor potensi dan halangan terhadap penggunaan BIM. Manakala, data temu bual adalah bagi menghuraikan secara terperinci setiap data soal selidik dengan mendalam. Dapatan kajian menunjukkan bahawa pembolehubah pengetahuan dan kos pelaksanaan adalah halangan utama mengapa firma reka bentuk dalaman tidak melaksanakan BIM. Diikuti oleh pembolehubah lain iaitu teknologi dan sumber manusia yang merupakan halangan untuk melaksanakan BIM dalam firma reka bentuk dalaman. Selain itu, firma reka bentuk dalaman yang berorganisasi besar tidak menghadapi banyak halangan dalam pelaksanaan BIM, manakala firma reka bentuk dalaman yang berorganisasi kecil menghadapi banyak halangan dalam pelaksanaan BIM. Seterusnya, daripada data kuantitatif dan kualitatif, satu rangka kerja konseptual dibangunkan untuk meningkatkan penggunaan BIM di firma reka bentuk dalaman. Rangka kerja ini telah dibincangkan dan disahkan bersama pakar reka bentuk dalaman dan bertujuan sebagai garis panduan dan rujukan bagi industri dan para akademik reka bentuk dalaman dalam meningkatkan penggunaan BIM. Kajian ini sangat penting kerana penyelidikan dalam penggunaan BIM untuk reka bentuk dalaman masih sedikit dan perlu dipertingkatkan dengan mengurangkan faktor-faktor halangan yang telah dikenal pasti.

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LIST OF ABBREVIATIONS

ID	-	Interior Design
BIM	-	Building Information Modelling
NIBS	-	National Institute of Building Science
NBS	-	National Building Specification
CIDB	-	Construction Industry Development Board
CREAM	-	Construction Research Institute of Malaysia
PWD	-	Public work Department
AEC	-	Architecture, Engineering and Construction
JKR	-	Jabatan Kerja Raya
CAAD	-	Computer-Aided Architectural Design
CAD	-	Computer-Aided Design
CAM	-	Computer-Aided Machining
UPE	-	Unit Perancangan Ekonomi
NIC	-	Newly Industrialized Country
NKEA	-	National Key Economic Areas
GDP	-	Gross Domestic Product
MSC	-	Multimedia Super Corridor
UTHM	-	Universiti Teknologi Tun Hussien Onn Malaysia
NCI	-	National Cancer Institute
MACC	-	Malaysian Anti-Corruption Commission
IPMS	-	Integrated Project Management Solution
ASID	-	American Society of Interior Designers
CIDA	-	Council of Interior Design Accreditation
BIDA	-	British Interior Design Association
IFI	-	International Federation of Interior Architects
MSID	-	Malaysia Society of Interior Design
LAM	-	Lembaga Arkitek Malaysia
MIID	-	Malaysia Institute of Interior Design

LIST OF SYMBOLS

s	-	required sample size
X^2	-	table value of Chi-Square for 1 degree of freedom at the desired confidence level (0.05 = 3.841)
N	-	population size
P	-	population proportion (assumed to be 0.50).
d	-	degree of accuracy expressed as a proportion (0.05)
ERn	-	Expertise Respondent

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This study describes the implementation and enhancing of Building Information Modelling (BIM) for the interior design industry in Malaysia. This chapter explains information such as the background of the study, problem statement, research aims and objectives, research questions, the scope of the study, the significance of the study, preliminary study and pilot study, originality and expectation from the study and organisation of chapters.

1.2 Background of Study

Nowadays, the construction industry is rapidly developing in terms of time and technology used. The increased use of technology in the construction industry has enabled the construction work from the beginning of the phase until the final phase to be carried out smoothly. The practice of innovative technology has been realized with the implementation of Building Information Modelling (BIM), which is a very efficient and demonstrative technology in all aspects, especially in the construction industry. Furthermore, it has changed how the construction industry works since it moves in an innovative paradigm with increasing productivity, efficiency, quality, while reducing project delivery time and cost to achieve its highest potential (Azhar *et al.*, 2008). BIM is a significant technology to implement since it adopts building development with different approaches based on the complexity of the construction phases (Chen and Qu, 2011). The impression of BIM is to construct a building virtually, preceding to building it substantially out the problems with the simulated and analyse the possibility waves (Smith, 2007).

Currently, BIM has been implemented in many countries such as the United Kingdom (UK), Australia, Hong Kong, Denmark, Norway, Finland and Singapore (NIBS, 2007). The United States of America (USA) is the first country to implement BIM (NIBS, 2007). In Malaysia, the idea to implement BIM was introduced by the Director of Public Works Department (PWD) in 2007 (Jabatan Kerja Raya (JKR), 2013). The construction industry in Malaysia has been seen as the most problematic industry due to costs overrun, delays, the production of low quality products, intensive labour as well as the usage of old technology (CIDB, 2009). This includes all disciplines such as architects, engineers, contractors, quantity surveyors and others. With this, the interior design profession also faces the same dilemma.

BIM is in the process to generate and manage the data related to the building design, construction and documentation by integrating with building geometry, spatial relationship, geographic information, and quantities of the building components (Lee *et al.*, 2006). The atmosphere in the construction industry has increased through the transferring of technology by implementing BIM. Numerous countries in the world have already implemented BIM, but in Malaysia, it is considered as a new technology approach in the construction industry.

According to Ayub and Eman (2006), the implementation of BIM in the Malaysian construction industry is still decelerated with facing specific problems and barrier matters (Table 1.0). They identified several problems that influenced the lack of BIM usage in the construction industry, such as lack of construction materials and machinery, lack of staff and labours, communication problems and others. These problems slowed down the BIM implementation in the construction sector, and as a result, the economy growth decreased.

Malaysian is still looking towards implementing BIM in the construction industry. Moreover, it has the problems while BIM is implemented such as lack of construction material, lack of staff and human resource, lack of knowledge and communication problems among designers and contractors. The beginning of era using the computer as a symbol of the information phase has brought boundless changes to all aspects of modern society. Interior design as a new industry, but also predictably be affected. Interior design with the development of the information age, showed the following trends: digital, exchange of information and convenient design tools, intelligent living space. Designers not only the information age to the

computer as a medium of modern design, is more important is to have quickly and accurately clench, control, and the ability to use a variety of information.

Table 1.0 BIM implementation problems in the Malaysian construction industry (Ayub and Eman, 2006)

BIM implementation problems	Insufficient instruction and information in the contract specification, drawing and design.
	Lack of construction materials and machinery.
	Inefficient and ineffective planning and management.
	Lack of staff and labours.
	Inexperienced labours.
	Lack of technical knowledge background among the contractor and the owner.
	Changed Conditions/Differing Site Conditions.
	Communication problems.

BIM provided a new approach in the design, construction and facility management through a 3D-based technology for design information, improvised design flair and design coordination (Eastman *et al.*, 2011). According to Eadie *et al.*, (2013), BIM is mostly adopted during the design stage (55%), detail design and tender stage (52%), construction stage (35%), feasibility stage (27%), and operation and maintenance stage (9%). The significance of BIM in the construction industry should be a serious effort for the construction players, especially in the Malaysian construction industry. The BIM process develops in a few stages, whereby the level of information collaboration recognises each stage. The processes of collaborated information are to find out the maturity of the BIM process (CIDB, 2016).

Figure 1.0 shows BIM technology according to its level, process and timeline. There are four levels in the process, namely conventional, modelling, collaboration and integration with the isolated, collaborative and integrated into the process phases. CIDB has proposed that Malaysia's construction industry is required to implement BIM in the year 2020 for enhancing the construction industry more effectively and efficiently. The different process will show the level of process based on the timeline and the maturity of BIM implementation.

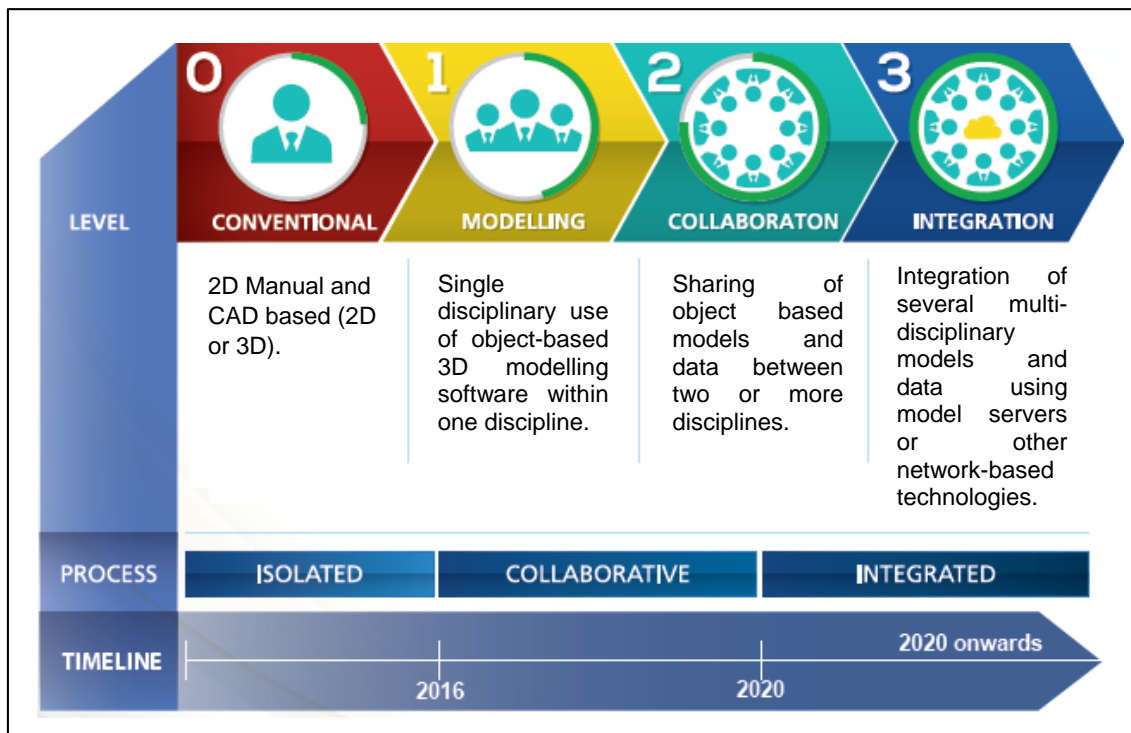


Figure 1.0 The BIM Maturity and implementation process (CIDB, 2016)

The development trend of interior design in the information age can be divided into three (3) groups which are digital design tools, convenient information exchange and intelligent living space (Yi and Wang, 2016). In the digital design tools, interior design should have followed the trend to make sure interior designers do the design faster and easier. A large number of interior design software is now more commonly used several software, two-dimensional (2D) drawing software such as Auto CAD, 3D modelling software 3D StudioMax, rendering plug Vary. The software for interior designers is to provide more forms and improving efficiency to promote the development of the interior design industry more realistic reflection of the final results.

Inconvenient information exchange, Interior designers can choose according to their designs suitable material, and timely communication with material suppliers to discuss the operational program. Interior designers can also find timelier and effectively in communication with customers through the network platform to allow customers to participate in the design to create with the design features, letting customer satisfaction designs. Furthermore, for the intelligent living space, the interior design has entered the intelligent life, which is leading the future direction of interior design.

The BIM technology in interior design will bring revolutionary changes, mainly in the several aspects which is BIM design software is no longer available only draw points, lines, circles and other geometric elements of simple drawing tools, but it can automatically generate the required expression of a variety of interior design drawings. The interior designers can take advantage of a three-dimensional model of scrutiny on any design perspective, to determine the material, colour finishes, lighting layout, fixed facilities, pipelines and collision checking member. The identification of the particular location of the pipeline through the member, thereby leading to a detailed analysis of the design, to ensure the quality of the design.

In Building Information Modelling, data relating to all the basic elements of construction works are stored in a unified database and information integration. This makes it possible to build the core BIM collaboration platform to make the interior design, electrical, plumbing and other various professional designers can expand the collaborative design on the same building model through the network, but also through collaborative work platform with the owner, construction suppliers, material suppliers and other coordination and communication and communicate information in a timely manner, information can be effectively managed and applications, designed to ensure coordinated and efficient, smoothly.

1.3 Problem Statement

Today, Malaysia has a huge crisis in the construction industry to increase their productivity, quality and value. This includes problems such as costs overrun, delays, the production of low quality products, intensive labour as well as usage of old technology (Zakaria *et al.*, 2013). In Malaysia, the implementation of BIM is still in its early stages, and only a few companies or organisations have implemented the BIM software in their organisations and construction projects (CREAM, 2014).

Currently, the research about BIM and the interior design industry are limited, and literature reviews are difficult to find. Most researches are about the construction industry, AEC industry, facilities management and management. This was supported by Santos *et al.* (2017) were between 2005 and 2015, more than 90% related BIM research was published after 2011, and this shows that more focus has been given on BIM in the recent decade. In Malaysia,

many research about BIM has been published, and there are many studies about BIM using semi-structured interviews to measure the perception of BIM among the construction players (Latiffi *et al.*, (2016 & 2017); Latiffi *et al.*, (2014); Zakaria *et al.*, (2013); Mustafa Kamal and Flanagan (2012); Mamter *et al.*, (2017) and Yusuf *et al.*, (2017).

Figure 1.1 shows the BIM tools in the construction industry recommended by the government, which is Revit Architecture, Revit Structural, Revit MEP, Naviswork and Cost-X. Figure 1.1 shows nil research about interior design tools even though interior design is also among the construction players. To obtain sources from literature reviews about interior design implemented by BIM were difficult. Due to that, a preliminary study was conducted to find more information and data regarding BIM usage in the interior design industry.

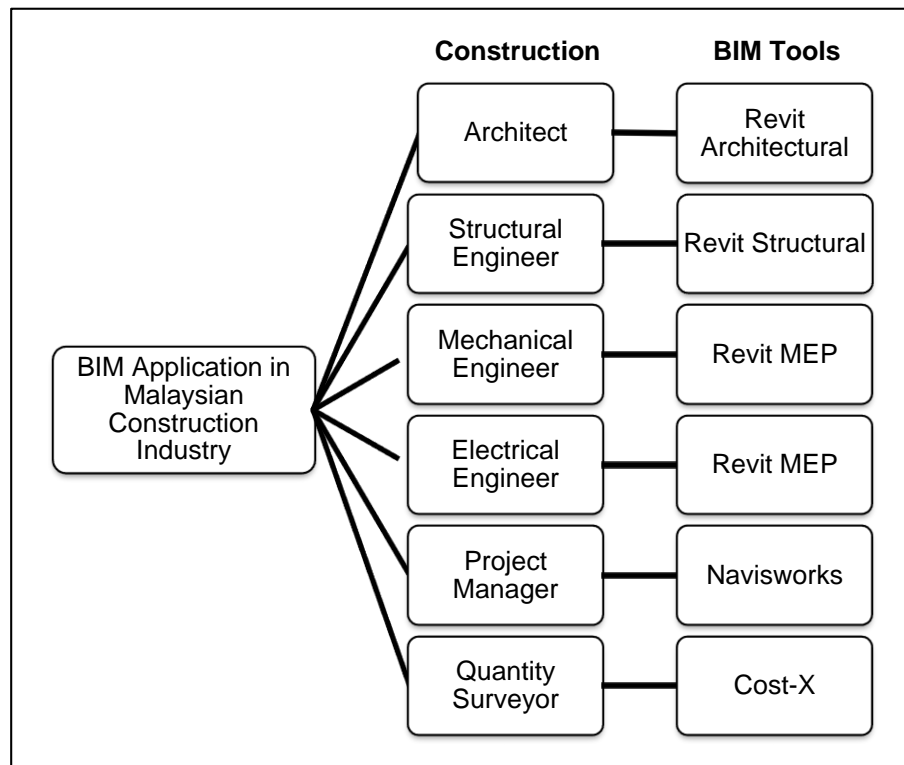


Figure 1.1 Diagram of BIM tools (JKR, 2013)

Today, BIM has become ubiquitous in the design and construction fields. In developed regions, the percentage of companies using BIM jumped from 28% in 2007 to 49% in 2009, and for 71% in 2012 (McGraw-Hill Construction, 2012). However in Malaysia, the architectural firms' BIM adoption rate was 20% (Mohd-Nor & Grant, 2014), and only 10% of quantity surveying firms involved in BIM adoption since BIM was introduced ten (10) years

ago (Ali, Al-Jamalullail, & Boon, 2013). Additionally, engineering firms were found being steadily slow implement BIM (Rogers, Chong, & Preece, 2015). As architectural, engineering, and surveying practices are the main players in the BIM working environment. This can be a significant indicator of slow uptake of BIM in the Malaysian construction industry as a whole especially for the interior design industry.

It has been observed that interest has been fast developing in the BIM software since it makes it easier for professionals to accomplish their work. Not all interior designers practice was supported with CAD software or any tools. Interior design in both fields could either be education or practice employed by various general-purpose software packages. Computer-Aided Architectural Design (CAAD) software was principally designed for general-purpose application and to be used for particular requirements (Kurman, 1998). Generally, software used by interior architectures is general-purpose software developed for architecture and customisation of software packages comparing requirements of interior design usage, which is left to the user (Senyapili and Gokcen Bozdag, 2012). Building Information Modelling is another technology tools in the building context other than CAD technology approach. The technology of BIM was significantly to improvise the level of integration of information to provide more quality and efficiency in the design and value of the development of the interior design industry (Yanwen and Xuguang, 2014). With the BIM technology, it has changed from the traditional design patterns two-dimensional drawings to new approaches of the design patterns, design processes and efficient designs for the excellent quality of the interior design construction.

Surprisingly, with the improvements of the technology, the interior design profession loses the grip of its design field, instead of having the upper hand. Not only contractors are producing optimised interiors based on cliché visions (Senyapili and Gokcen Bozdag, 2012), which are nonetheless professional looking thanks to the computer aid; even clients are becoming capable of creating their images of the interiors through the do-it-yourself packages (Chu, 2003). As stated by Coates *et al.*, (2010), BIM mostly focuses too much on the final form of the design and most designers still preferred using traditional methods by pen and paper to sketch the ideas, and BIM tools fail to allow talented designers in the design process to accommodate the uncertainties of the early design stage.

Interior design is a specialist in the design perspectives compared to other fields in the construction industry. It is about the detailing design in interior space according to the requirements such as colour, lighting, texture, furniture fixing, finishes and materials and detailing of ergonomic and proportion of human scale (Coles and House, 2007; Kurtich and Eakin, 1993). The paradigm for specialised trained in both the architectural arts and computer sciences, interior design, architecture and engineering education should be preparing a workforce for BIM technology. Talented and technically trained AEC designers will shape the visual 3D world using new tools that will help them to control the data found within the model. As part of a techno-economic shift, BIM may be able to create jobs while helping people achieve a better quality of life (Bounds, 2015).

1.4 Preliminary Study and Pilot Study

This research is conducted to identify the issues and problems BIM had with interior design firms. These were obtained via interviews and questionnaire surveys. Random sampling method was used to determine the sample size for this study as it was appropriate to be applied for a preliminary study in which a complete list of the population was available (Kumar, 2014). Generally, there are more researches in other construction industries such as architecture, construction, facilities management and engineering but the interior design still lacks research in terms of about Information and Communication Technology (ICT), software and hardware, BIM knowledge and awareness and readiness on BIM usage. Thus, there is a possibility to implement BIM in the interior design industry.

The interior design practice, Mr Azim, Design Director, Radius GSA (2017) had mentioned that the research is limited to BIM implementation for interior design practitioners since there are still a small number of users. According to Mr Azim, their company already used BIM around five years and still struggle to find out the person competent in BIM software to do some interior design projects related to BIM technology. He is also agreed that without any knowledge and skill, the process of design and documentation were a disaster. The limitation of knowledge and less the sources to implement BIM were determined how crucial the BIM usage in the interior design industry. Consequently, another interior design practice, Mr. Azrin, BIM Director, GDP Interiors (2017) had discussed the same topic about BIM in the

interior design industry which still have gaps. There are has a few barriers need to justify, such as technology, knowledge, cost, and human capital.

According to the preliminary study, the interior designer, Mr. Jefree Ismail (2015) mentioned that BIM in Malaysia is still new and most of the interior design firms are unable to use BIM technology due to several constraints on cost, software and hardware, besides hiring staff with BIM knowledge and specific projects using BIM base on the clients' request. These constraints were supported by the Interior Design Director of IRISS Interior Design; Mr. Jamal (2015). He mentioned that interior design in Malaysia is still left behind compared to others in the construction industry in Malaysia. But we (interior designers) are aware of the priority and benefits regarding BIM usage and ready to implement BIM if there are any initiatives or incentives from the government and board of professional bodies. The ability of contractors to deliver the new technology also makes it barriers to achieve the above process.

According to Connelly (2008), extant literature suggests that a pilot study sample should be 10% of the sample projected for the more extensive parent study. However, Hertzog (2008) attentions that this is not a simple or straight forward issue to resolve because many factors influence the types of studies. Nevertheless, Isaac and Michael (1995) suggested 10 – 30 participants; Hill (1998) suggested 10 to 30 participants for pilots in survey research. This research implemented according to the Isaac and Michael statements to approval the quantity of sample in the pilot study.

In order to find out the problems of interior design firms to implement BIM, the pilot study was conducted by chosen sixteen (16) interior design firms were involve in this survey. The survey was conducted by distributing the questionnaire to interior design firms in randomly in Klang Valley, and the result was analysed based on the data, as shown in Figure 1.2. The pilot study will determine the current situation of BIM using for the interior design industry in Malaysia. It will determine several issues of how is the interior design firms can enhance BIM usage and readiness factors.

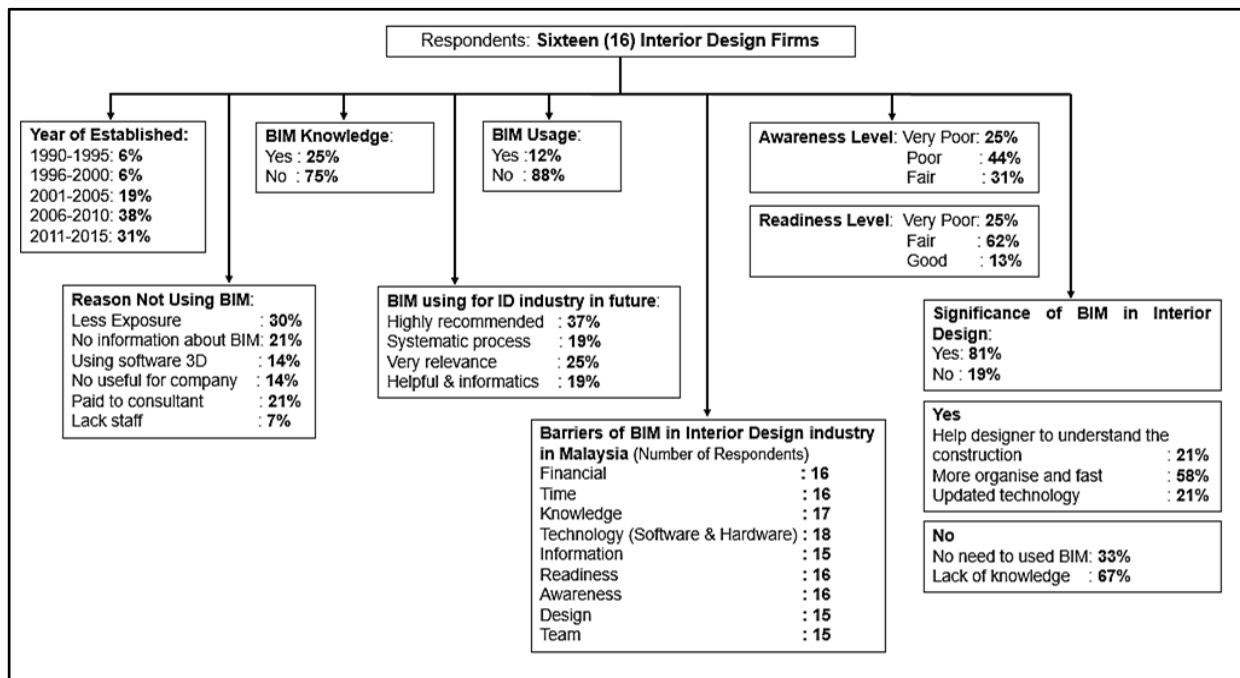


Figure 1.2 Summarise of Result from the Pilot Study

As a pilot study result, the establishment of firms from the year 2006 to 2010 is thirty-eight percent (38%), the year 2011 to 2015 is thirty-one percent (31%) and the following year 2001 to 2005 with nineteen percent (19%). In the year 1990 to 1995 and year 1996 to 2000 with six percent (6%). According to the survey, most of the interior design firms are considering still a new firm with less ten years' establishment. Reflected the percentage of firms' establishment, the data show the BIM knowledge among interior design firms are deficient with seventy-five percent (75%) do not have or lacking knowledge but only twenty-five percent (25%) knowing about BIM. From the result, with the small percentage (25%) of BIM knowledge, it is definitely shown that the atmosphere how the serious situation for the interior design industry to used BIM.

Based on the pilot study, most of the interior design firms are still unclear about BIM usage and benefits and whether it should be implemented in the interior design industry. They are still reluctant and lack confidence in adopting new technology. These problems were supported in Figure 1.3, which analyses the Level of Awareness and Level of Readiness. The Level of Awareness shows that more than fifty percent (50%) are not aware, compared to only thirty-one percent (31%) who can be considered aware of BIM technology. Meanwhile, the Level of Readiness shows that the interior design firms are ready to use BIM with sixty-two

percent (62%) and thirteen percent (13%), respectively. However, twenty-five percent (25%) are not ready to use BIM and also awareness level is equivalent.

According to Figure 1.3, it was found that the gap factors for interior designers are very high compared to other construction consultants. The awareness and readiness level are very crucial since BIM usage among the interior design firms are very low. From the preliminary study and literature review, this thesis intends to investigate why interior design firms are not ready to use BIM. The result from preliminary will identify the opportunity and barriers of BIM implementation in interior design and finally follow with designing a framework to enhance the readiness of BIM implementation in the interior design firms. The framework of readiness of BIM implementation for interior design firms will determine the gap in this research through data analysis and findings. The interior design industry is ready to implement BIM, but a more detailed discussion is needed to consider factors to implement BIM. This matter will be discussed in Chapter 5 and 6 of this study.

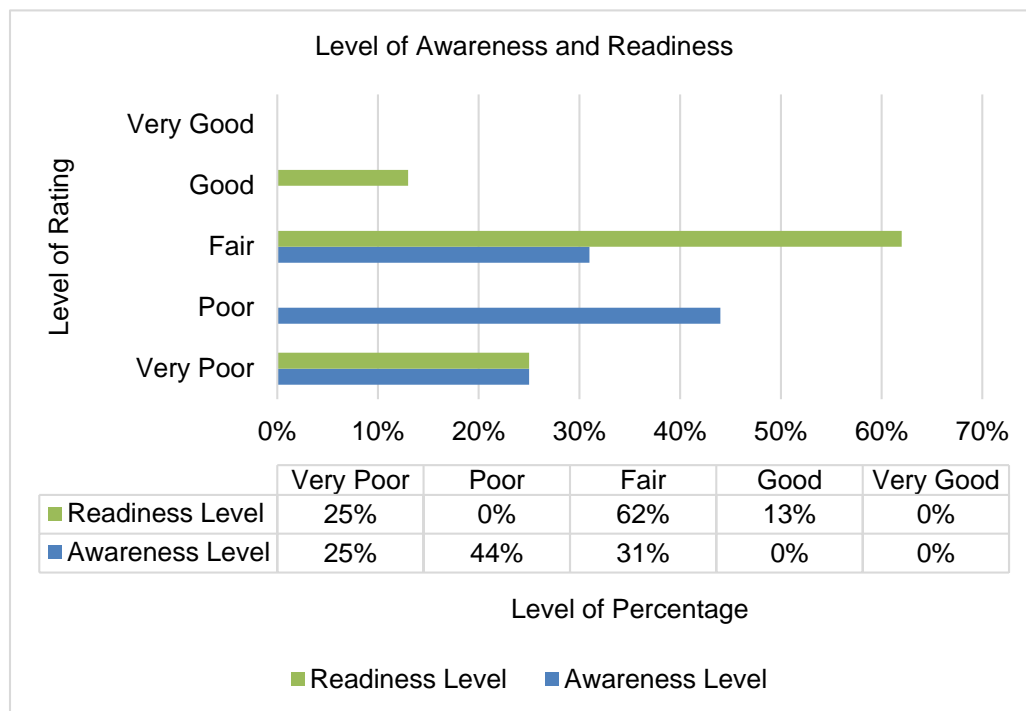


Figure 1.3 Summarizes Level of Awareness and Level of Readiness

Figure 1.4 shows the frequency of BIM usage in interior design firms. It is about eighty-eight percent (88%) the respondents not using BIM technology. It is very crucial in the implementing of BIM in the interior design industry. However, only twelve percent (12%) used

BIM which is six percent (6%) understanding for construction in BIM and six percent (6%) easy and fast when used BIM.

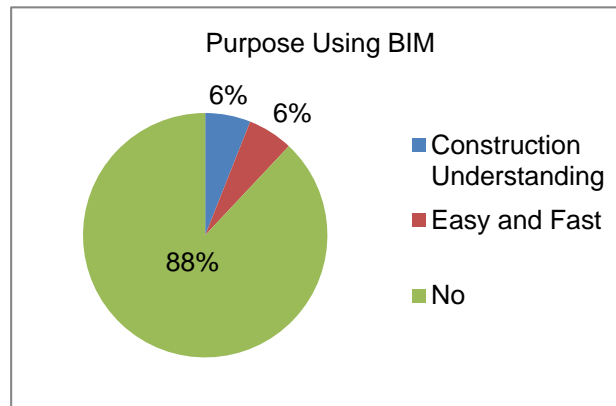


Figure 1.4 Frequency of Using BIM in the Interior Design Firms

Figure 1.5 shows the reasons why the interior design industry is not implementing BIM based on less exposure which is the main reason at 30%, followed by no information about BIM (21%), outsource consultant (21%), 3D usage in ID (14%) and not using BIM for company (7%). This trend shows that interior design industries are still far behind in terms of knowledge, awareness and implementation of BIM while other fields in architecture, engineering and construction (AEC) have already adopted BIM.

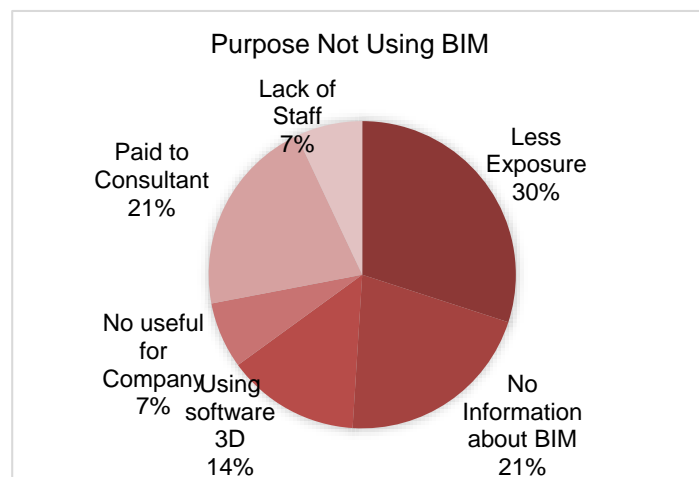


Figure 1.5 The factors not using BIM in the interior design firms in Malaysia

1.5 Research Aim and Objectives

In order to correlate with the significance of this study, this research aims is to identify methods to improve the readiness of BIM implementation for the interior design industry in the Malaysian context. This improvement will be supported through the development of framework by finding barriers, variables of BIM and the current framework for interior design. To achieve this aims, this study was supported by several objectives:

- (a) To explore the current implementation of BIM for the interior design industry to the fundamental problems in the organisation.
- (b) To evaluate the level of readiness and awareness criteria of BIM in the interior design firms.
- (c) To develop a conceptual framework of the readiness criteria for implementing the achieved BIM status.
- (d) To validate the readiness by validating and refining the readiness criteria design for BIM in the interior design firms.

1.6 Research Questions

In order to design and develop the methods to improve the readiness for the interior design using Building Information Modelling (BIM), several questions pertaining to the subject were highlighted, as follows:

1. What are the barriers that interior designers faced during the implementation of BIM?
2. How crucial are these barriers when BIM is implemented in the interior design industry?
3. What is the significant relationship between the size of interior design firms and barriers in BIM?

4. What is the level of readiness and level of awareness for BIM implementation in the interior design industry?
5. How efficient can BIM help interior designers to improve their skills and knowledge?
6. How can the readiness framework improve the interior design firms using BIM?
7. What is the method to evaluate the readiness of the BIM in the interior design industry?

1.7 Significance of the Study

The main purpose of this study is to identify the causes of why BIM technology is not used in the interior design industry while others in the construction industry have done so. It is quite unlikely that the interior design is behind for not implement BIM technology in the industry. To convey this significance, this study will be addressing the factors of implementation and barriers of BIM in the interior design industry. The barriers will be identified from the many factors and criteria as to why BIM was not implemented and framework design will be conducted to recommend the solution on adopting BIM in the interior design industry.

This study is very significant in enhancing the interior design industry for applying BIM to ensure they are not left behind in the current technology. Since the context of the BIM usage is still minimal, therefore the findings and conclusion determined the many aspects from the supporting literature review and preliminary study. Consequently, the variables were identified to know the gaps and solution to the critical factors of BIM implementation. Furthermore, there is no description of interior design implementing the BIM technology, especially in the Malaysian context.

1.8 Scope and Limitation of the Study

The purpose of this research has some limitations related to the study to approach BIM usage. The main justification of having a research scope of this study is to develop and validate

the BIM implementation for interior design firms in Malaysia among different sized firms. This scope was supported by several variables and barriers to approaching the state of the readiness of the interior design industry using building information modelling.

There are many studies about BIM which focus on architecture, engineering and construction (AEC), facilities management, 3D information model and digital innovations. However, researches on the implementation of BIM for Interior Designers industry are still untapped and lacks information. The limitation of the literature review on the implementation and effectiveness of BIM in the interior design industry is still limited when describing the adoption of BIM. Constraints and problems in the implementation of BIM were identified as the reasons for its lack of use in this industry.

In this research, the numbers of respondents are sixty-three (63) interior design firms which were chosen according to the registered firms recognised by the Board of Architect Malaysia or also known as Lembaga Arkitek Malaysia (LAM). Searching and evaluating the cause of constraints and effectiveness is very significant. All results and analysis depend on the success of this study. Thus, the findings and conclusion of this study hope to help in the research and development of the relevant literature.

1.9 Originality and Contribution of this Study

The contribution of knowledge in this study hopefully can enhance the quality of design progress for the construction industry generally and the interior design industry especially in the Malaysian context. This contribution can be done in two circumstances - theoretical and practical aspects. The purpose of this study is to enhance the interior design industry implement Building Information Modelling (BIM), and at the end of this study, an improvement method in readiness was developed to guide the implementation of BIM technology for interior design and implement the method as a reference for the interior design industry.

The contribution to the knowledge of this research can be organised into two contexts which are theoretical and practical. Within the theoretical context, the main deliverable of this study which is the organisation readiness methods, will contribute to the current body of

knowledge. Since the approach that was engaged is qualitative, the readiness method is expected to be informative and more understandable to refer. Meanwhile, within the practical context, since the readiness method was developed based on the practical application within the Malaysian construction industry, it could be used as a comparative guide or readiness assessment tool to evaluate the investment of BIM. The framework is expected to be used by the interior design consultants, and it can assist in informing the organisation on the expected target needed to be achieved so the strategy can be formulated. For the academician field, the syllabus about BIM can be added in the course of interior design and the syllabus of BIM can enhance the knowledge and skill in early learning in the institute of higher education. Additionally, the comprehensive investigation which covers People, Process, Technology, and Management will also provide documentation of reference for BIM practice in Malaysia.

1.10 Structure of the Thesis

This study was designed as a part of action research according to framework development and validation as the evaluation process. Action research is the role of the researcher to participate in the examined process which is focussing on the research process and producing practical and valuable knowledge (Reason and Bradbury, 2007).

The structure of this thesis is organised into seven (7) subsequent chapters to create a flow and is summarised as the following:

Chapter 1 introduces the background of the research. This introduction will provide an overview of the thesis for a better understanding of the research topic. In this chapter, statements of the problem, research aims and objectives, research questions, the significance of the study, scope and limitation of the study and contribution of the study are explained.

Chapter 2 describes the literature on previous researches conducted along with the same subject. It determines the overview background of the interior design, definition of the interior design profession in all aspects related to interior design. BIM aspects will also outline the overall view from the literature review in terms of definition, usage, conceptual and theory of BIM.

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