A STUDY OF BUILDING INFORMATION MODELING (BIM) IN MALAYSIA CONSTRUCTION INDUSTRY

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

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DECLARATION

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

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APPROVAL FOR SUBMISSION

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DEDICATION

To:

My Beloved Family, Friends and J’ven Ng

Thank you for your love and support.

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ABSTRACT

Building information modelling (BIM) is a technology that is currently gaining momentum within the construction industry as interoperability issue is become more and more important in relative to the quality and productivity of the industry. BIM is defined as a modelling technology and associated set of processes to produce, communicate, and analyse building models throughout the entire project's lifecycle. Although there is bound of benefits that gained from the BIM application, the local construction industry still reluctant to deploy the technology in delivery its services. The objectives of the study include identifying the level of usage of technology within the construction industry, identifying the barriers for the implementation of BIM, the potential driving factors in accelerating the BIM adoption and the consequences if BIM has being adopted in the local construction industry. The survey questionnaires were distributed in the construction field within Kuala Lumpur region. There are 70 sets of questionnaire have been collected back. The main conclusion drawn from the study are that the high level of ICT usage among the construction professionals has make the industry more readily in emerging BIM and the identified barriers can confined into three main categories: people, capital and environment oriented. Furthermore, the research has identified the potential factors that driven the adoption of BIM and also the consequences of mandating BIM adoption in the local industry.

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CHAPTER 1

INTRODUCTION

1.1 Background

Construction industry is moving rapidly towards the modernization. Information Communication Technology (ICT) has played the significant roles in this transformation. The use of ICT permeates various industries and is seen as a major driver for improvement in performance and cost efficiency (CIDB, 2006).

However, the performance of the ICT towards the industry still underprivileged. It might be due to the different types of software used by the participants of the industry, the amount of redundant information and the manual transfer of information (Molnar, Andersson, & Ekholm, 2008).

To solve the problem, Building Information Modelling (BIM) has been introduced to the industry. BIM is suitable to support the simulation of a construction project in a virtual environment, with the advantage of taking place *in silico* through the use of a proper software package (Jardim-Goncalves, 2010). Unfortunately, people tend to develop the related software tools that tend to address interoperability among themselves only and not in relation to other vendors' application. Although the adoption of BIM is expanding within the industry and it have been beneficial several parties. Yet, there is still some space for improvements.

Even though the concept of BIM has been widely implemented, but people still failed to explore how a BIM can really talk to a construction project in a real-time manner (W.S.Lu & Li, 2011).

Therefore, this research will aim to study how the BIM will interoperate with the construction project and also will investigated the appropriate approach to enhance it.

1.2 Problem Statement

Interoperability issue become increasing important within the construction industry as it will affect the productivity and quality of a project. BIM technology has been introduced in order to solve this problem. However, the adoption is still low in local construction industry. Despite that, there are some barriers when dealing with the BIM. As Datuk Seri Prof Judin Abdul Karim said “It is not a problem of knowledge and information on the usage of ICT; it is always about the cost.” Although there is awareness of using the ICT but the cost of investment prohibited companies from adopting the technology. Big companies can afford ICT investment while most of the small companies find its adoption unaffordable (Star, 2009). Therefore, this research will identified the barriers when dealing with the widespread of BIM adoption which not only in the monetary term but also others related issues such as legal issues, data-storage capacities, availability of real-time information and et cetera.

1.3 Aim

The primary aim of this research is to investigate the issues of Building Information Modelling (BIM) adoption in local construction industry in order to resolve the interoperability issues.

1.4 Research Objectives

In order to meet the aim mentioned above, the research objectives are as follow:

- To study the current practice and awareness of the industry towards the new technologies.
- To investigate the barriers of Building Information Modeling (BIM) adoption in construction industry.
- To identify the potential factors that could accelerate adoption of Building Information Modeling (BIM).
- To envisage the consequences if Building Information Modeling (BIM) has been adopted.

1.5 Scope of Study

This research is focused on the participants of the construction industry which generally divided into few groups: Developers (owners), Architects, Consultants, Engineers and Contractors to get their opinions towards the Building Information Modelling (BIM) adoption in solving the interoperability issue. The respondents are chosen based on the top management level and the middle management only. In addition, the research will only focus on the construction firms that located within the Klang Valley area, state of Sabah and Sarawak were not included.

1.6 Project Organization

Chapter 1: Introduction

In chapter 1, the outline of the project will be illustrated. It consists of the background of studies, problem statement, and the aim of research, research objectives, scope of study and the project organization for this paper.

Chapter 2: Literature Review

While in Chapter 2, the information about the research title will be obtained from different sources such as journals, books, web site and et cetera so that the concept of the research can be supported by facts and to prove the feasibility of the research title, aim and objectives.

Chapter 3: Research Methodology

For chapter 3, the research strategy, research method and data analysis that will used for this project will be explained and the information and data collected will be interpreted.

Chapter 4: Findings and Analysis

Moreover, in Chapter 4, the outcome of the analysis of data collected from the questionnaire will be presented and it will be supported by the facts that mentioned in the Chapter 2 in order to clarify the perceptions of the participants towards the project's objectives and aim.

Chapter 5: Conclusion and Recommendation

Lastly, the main conclusion will be drawn out in this chapter and the limitations of the research will be highlighted at the meanwhile. Except from that, some of the opinions/points will be recommended for the purpose of further investigation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter covers the basis information about Building Information Modeling (BIM) which includes the concept of BIM, the barriers to BIM implementation such as legal issues, interoperability, major stakeholders' support, resistance to change, operator competencies are also discussed. Moreover, the strategies for the implementation of the technology which include training, development of parametric library will also presented in this chapter.

2.2 Nature of Construction Industry

The construction industry has lagged behind other industries in accepting the benefits of adopting Information Communication Technology (ICT). In the 1990s, while interoperability productivity benefits were being realized in other industries and the building construction industry went largely unaffected. Much of this was due to the fragmented nature of the industry where relationship between designers, contractors and subcontractors often inhibited communications and teamwork. The problem was compounded further by the fact that many design and construction firms were small and did not have resources required to take full advantage of new information transfer technologies (Gabriel & W.Jun).

The fragmented nature of the industry who involved a wide range of parties from the blue collar labour: carpenters, bricklayers until the white collar workers: Engineer, Architects, Quantity surveyors and et cetera with play with different roles and duties in order to faster the development of construction industry which include: Designer (Architect and Engineer), Consultants (Quantity Surveyor), Construction team (Contractor) and et cetera. To cope with the improvement of the Information Communication Technology (ICT), the professions have been developed their own construction-related software for the ease of their works. However, they only utilized it within their own department or within their profession's group. The interoperability within one groups and another still is an issue within the industry.

2.3 Role of Construction Professionals

Building construction requires many workers and many trades. From the perspective of realising a project, a professional project team is needed to make sure that project will be constructed successfully. The construction professionals include the architect, engineer and quantity surveyor. They are the most responsible person in a project especially when technical works are concerned. Thus, the expertise of each construction professionals must be carefully exercise as they are answerable to any sinfulness occurred during the construction (Hussin & Omran, 2009).

2.3.1 Client

The client's role is to provide leadership and a mandate for change. Whether or not the client becomes directly involved in technical issues is a matter of choice, but what is important is and the client is seen by the rest of the design and construction team to be committed and sufficiently knowledgeable to be committed and sufficiently knowledgeable to be decisive and set clear requirements.

2.3.2 Architect

In general, architect is a person who is involved in the planning, designing and oversight of a building's construction. In the broadcast sense, an architect is a person who translates the user's needs into the builder's requirements. The knowledge about the building and operational codes is necessary so that he or she is not apt to omit any necessary requirements, or produce improper, conflicting, ambiguous, or confusing requirements. Furthermore, architect must understand the various methods available to the builder for building the client's structure, so that he or she can negotiate with the client to produce a best possible compromise of the results desired within explicit cost and time boundaries. Then architect also responsible with being familiar with the construction work and reporting the general progress and quality of the work, as completed to the owner (Hussin & Omran, 2009).

2.3.3 Engineer

The scope of work of engineers involves planning and execution of the designs from transportation, site development, and hydraulic environmental, structural and geotechnical engineers. The main part of engineers' job description is analyzing report which includes the analysis of maps, drawings, blueprints, aerial photography, topographical information, calculation of the building loads and analyzes the grade requirements and et cetera. Engineers also have to make sure that there are no impediments in the way of where the structure will be built and if there are any they must move them. Finally, the engineers have to provide construction information, including repairs and cost changes to the managers (Hussin & Omran, 2009).

2.3.4 Quantity Surveyor

Quantity Surveyor is the person who manage and control costs within construction projects and may involved the use of management procedures and technical tools to achieve this goal. The method employed cover a range of activities such as: cost planning, value engineering, feasibility studies, cost benefits analysis, lifecycle costing, valuation and cost estimation. A quantity surveyor can also be known as construction economists, cost engineers or construction managers. Quantity Surveyors control costs and prices of work, labour, materials and plant required, an understanding of the implications of design decision at an early stage to ensure that good value is obtained for the money to be expended. Quantity surveyors will also preparing tender document in accordance with a published standard method of measurement as agreed to by the quantity surveyor profession and representatives of the construction industry (Hussin & Omran, 2009).

2.3.5 Builder/Contractor

A contractor sources materials and manages the construction process. This involves both direct material purchase and indirect purchasing through trade contractors. Therefore, the contractor is the party responsible for agreeing with the design team how they will meet the client's requirement for recycled content and et cetera. The contractor's task is then to source and incorporate specific products that satisfy or exceed the client's requirement into the works as specified. On completion, the contractor should be able to provide the client with documentary evidence that the target level of the project had been achieved.

2.4 The Concept of BIM

Building Information Modeling (BIM) represents the process of development and use of a computer generated model to simulate the planning, design, construction and operation of a facility. A BIM is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users ‘needs can be extracted and analyze to generate information that can be used to make decisions and to improve the process of delivering the facility (AGC, 2005).

While, Wong et al. said that BIM has the attributes of both an approach and a process/action. It is an approach as it provides an alternative to the traditional paper based approach of project design and management. It is also a process/action as it creates a product called Building Information Model, whose performance can be measured.

BIM is actually the intersection of two critical ideas: (Autodesk, 2003)

- Keeping critical design information in digital form makes it easier to update and share and more valuable to the firms creating and using it.
- Creating real-time, consistent relationships between digital design data – with innovative parametric building modeling technology – can save significant amounts of time and money and increase project productivity and quality.

BIM is now rapidly gaining acceptance as the preferred method of communicating the design profession’s intent to the owner and project builders (Bruce A. Burt, 2009). In addition, BIM now is also being increasingly used as an emerging technology to assist in conceiving, designing, construction and operating the buildings in many countries (Wong et al., 2009).

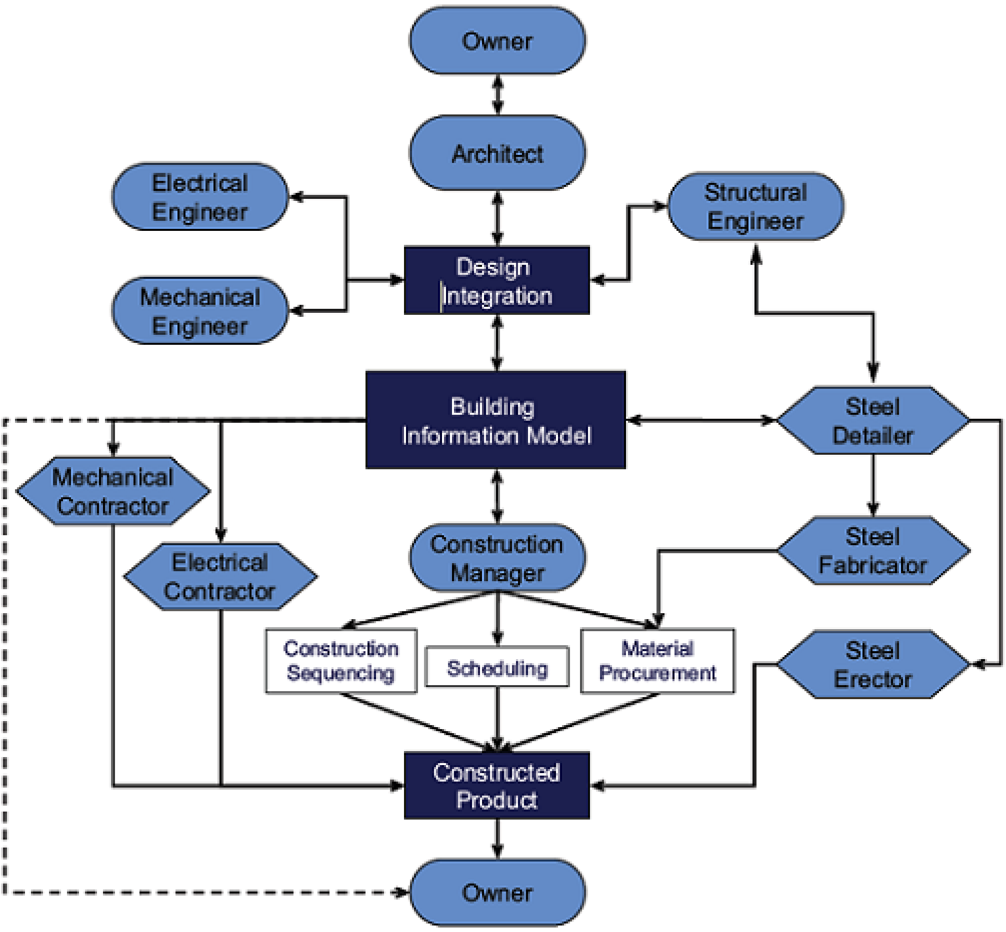

Figure 2. 1 The Concept of BIM (Bruce A. Burt, 2009).

2.4.1 Function of BIM

According to editor of BIM journal (2012), BIM has a broad range of application, right cross the design, construction and operation process. These BIM functions can be roughly grouped into five categories:

- Design
- Analysis
- Construction
- Operation
- Data Management

Design applications relate to the pre-planning and planning phase of a project. This section includes initial data collection (laser surveying, existing conditions modeling and site analysis), spatial programming and design authoring. It encompasses includes design review and coordination.

Analysis refers to secondary applications, often undertaken by a party who may not have authored the model themselves. Analysis activities include structural analysis, energy analysis, 'green building' certification, lighting analysis, mechanical analysis, as well as other specialty disciplines. This category also includes model auditing, that is validating model integrity and verifying the model against design parameters and building code requirements.

Construction functions refer to the deployment of BIM for construction management. This includes construction planning as well as applications for construction sequencing (4D) and quantity take-off and estimation (5D). This section also examines shop drawing production and integration with Computer Aided Manufacturing (CAM). A significant part of this section addresses 'BIM to Field' activities such as establishing construction set-out points and recording as-built data and construction status.

Operation refers to BIM functions that support facility management. This includes record modeling, model maintenance and integrating the model with Facilities Management software for asset or spatial management, equipment tracking and maintenance scheduling. This section also examines how a model can be reactivated for future facility expansion.

Data Management examines best practices for BIM data structure and exchange, and how multi-model data may be regulated. This section includes an introduction to collaborative platforms and electronic project delivery systems, as well as key sessions on model collaboration, change management and issue reporting & tracking. This section also includes functions relating to interoperability and exchange formats (such as IFC), managing metadata and linking multiple databases (model & text file).

2.4.2 Benefits of BIM

Due to the nature of BIM software, there are several wide ranging benefits to be gained by deploying BIM. Basically, the advantages of BIM technology are a means either to reduce cost, materials usage or indirectly through efficiency gains throughout the three major phases in the building lifecycle: design, construction and management (Autodesk, 2003). While when look into the individual elements, the main benefits that drive the deployment are: (Davidson, 2008)

- Accuracy and consistency of data
- Design visualization
- Ease of quantity takeoff
- Multi-user collaboration
- Energy efficiency and sustainability

2.4.2.1 Design Phase

During the course of a building project, an architect must balance the project scope, schedule and cost. By using BIM, all of the critical information such as design- and geometry- information is immediately available, so that project-related decisions can be made more quickly and effectively. Furthermore, BIM allows a project team to make changes to the project at any time during the design or documentation process without laborious, low-value re-coordination and manual checking work. In addition, all of the building design and documentation work can be done concurrently instead of serially, because design thinking is captured at the point of creation and embedded in the documentation as the work proceeds. Lastly, the automatic coordination of changes offered by BIM would eliminate coordination mistakes, improves the overall quality of the work and helps companies win more repeat business (Autodesk, 2003).

2.4.2.2 Construction Phase

During the construction phase, BIM makes available concurrent information on building quality, schedule and cost. The builder can accelerate the quantification of the building for estimating and value-engineering purposes and for production of updated estimates and construction planning. The consequences of proposed or procured products can be studied and understood easily and the builder can quickly prepare plans showing site use or renovation phasing for the owner, thereby communicating and minimizing the impact of construction operations on the owner’s operations and personnel. The result is that, less time and money are spent on process and administration issues but goes into the building (Autodesk, 2003).

2.4.2.3 Management Phase

In the management phase of the building lifecycle, BIM makes available concurrent information on the use or performance of the building, its occupants and contents, the life of the building over time and the financial aspects of the building. Moreover, the provided digital record of renovations accelerates the adaption of standard building prototypes to site conditions for businesses of similar buildings in different locations. Furthermore, BIM also provide the physical information about the building such as finishes, furniture and equipments or financially important data about leasable areas and rental income or departmental cost allocations are all more easily managed and available. Generally, it can conclude that the consistent access to these types of information improves both revenue and cost management in the operation of the building (Autodesk, 2003).

2.5 Implementation of BIM

Building information modeling (BIM) is becoming more and more important to manage complex communication and information sharing processes in collaborative building projects (Sebatian and Léon, 2010). BIM is now increasingly used as an emerging technology to assist in conceiving, designing, constructing and operating the buildings in many countries, notably in the United States. Other countries including Finland, Singapore, Denmark and Norway have also adopted BIM (Wong et al, 2009).

2.5.1 Barriers to BIM in Construction Industry

People, technology and the environment are critical to implementation of BIM (Alshawi, 2008). People and process are keys to change and improvement, while work environment and IT infrastructure are enablers without which the first two elements cannot be sustained (Bew and Underwood, 2010).

In the market, much of the research devoted to BIM is focused on developing technological solutions aimed to standardize and streamline adoption across the design, construction and operational phases of a building. However, recently completed research indicates that a range of determining the success or otherwise of BIM adoption. It found these behaviors collectively resulted in the formation of a differentiated project team culture, sub-optimal ICT usage, and minimal utilization of BIM capabilities (Brewer et al., 2010).

Thus, the intention to adopt comes always first in the adoption process (Nikas et al., 2006). For example, top manager’s intention to adopt innovations is an indicator of their subsequent decisions (behavior). Therefore, it can conclude that, executive who categorize innovation as functional will intend to decided in favour of adopting the innovations with a belief in the potential gains or benefits from this innovation (Nikas et al., 2006).

Further, Nikas et al. (2006) also stated that, organizations satisfied with proprietary systems in conjunction with the existence of an existing IT infrastructure are more enthusiastic in adopting collaborative technologies. Additionally, they also revealed that for organizations that already have an IT department, the continuous training and skills development of their personnel is positively related with the intention to adopt collaborative technology.

However, the critical factors in implementing BIM application not only limited to people’s attitudes towards the technology, characteristic of the industry and project, individual’s resistance to change, it also related to the risks involved in the transformation, the uncertain outcome of the new technology and et cetera.

2.5.1.1 Interoperability

Interoperability is the ability to manage and communicate electronic data among owners, clients, contractors, and suppliers, and across a project’s design, engineering, operations, project management, construction, financial, and legal units. Interoperability is made possible by a range of information technology tools and applications including computer-aided drafting and design (CADD), three- and four-dimensional visualization and modelling programs, laser scanning, cost-estimating and scheduling tools, and materials tracking (NAP, 2009).

Effective use of interoperable technologies requires integrated, collaborative processes and effective up-front planning and thus can help overcome obstacles to efficiency created by process fragmentation. Interoperable technologies can also help to improve the quality and speed of project-related decision making; integrate processes; manage supply chains; sequence work flow; improve data accuracy and reduce the time spent on data entry; reduce design and engineering conflicts and reduce the time spent on data entry; reduce design and engineering conflicts and the subsequent need for rework; improve the life-cycle management of buildings and infrastructure; and provide the data required to measure performance (NAP, 2009).

However, modernization of the workplace has long been a topic for research and innovation. The main challenge is to realize real innovation and change in the workplace, and cope with the many hurdles-human, organizational, societal, and technological-through learning and experimentation. Considering AEC-FM domains, innovation of the workspace is of major importance, as practice is intrinsically collaborative, within knowledge-rich, multi-functional working environments. The evolution of sophisticated CAD systems, in addition to handling vectorial data, has made it possible to enrich the 3D models of buildings and structures with complementary data, enabling the simulation of a construction project in a virtual environment. This has emerged as major trend, usually known as Building Information Modeling (BIM) (Grilo & Jardim-Goncalves, 2010).

2.5.1.2 Stakeholders

Major stakeholders play an important role for the implementation BIM especially the support of the central government which can be regarded as the driving force towards higher utilization of BIM. A strong government support not only would create a uniform environment for nationwide acceptance of BIM, an active environment for research and development also would be created.

On the other hand, a strong involvement of private sector in BIM initiatives would help create new business processes, partnerships and collaborations. The involvement of private sectors would influence strong commercial incentives for developing new software or increasing the capabilities of existing software or hardware used for BIM. However, the creation of less uniformity environment may not be well compatible with other companies and thus the fragmentation of the real estate and construction companies would increase. This scenario is reminiscent of many developing and under-developed countries where implementation of BIM at both the public and private sector is at the initial stage or is non-existent (Wong et at., 2009).

2.5.1.3 Modeling Guidelines

As refer to the USA or UK which are success in changing the construction practice, their governments are setting out a BIM guideline in helping the industry in facing the changes and also provides several research in proving the viability of BIM. However, if without the private sector's support, the implementation of BIM also will not be success in the acceptance of nationwide. Therefore, it should be noted that modeling guidelines is essential in accelerate adoption of BIM and the successfulness of BIM implementation is depends on the cooperation between the public and private sectors.

2.5.1.4 Client's Demand

In the local industry, many stakeholder are scare of change or scare of the uncertain outcomes of the changes and most of the clients will only willing to change if the benefits are proven and they believe that the request of the new technology for a project will enable the bidders to increased their bid's price of the project and thus will limiting their potential pool of bidders. Whilst, the contractor may have the intention to change when they facing keen market competition, there are strong incentives for it to search for new innovations to help maintain or enhance its competitive edge.

2.5.1.5 Pilot Project

The uncertainties of the outcome are one of the barriers in implementing BIM. Therefore it is best to start out with a pilot project that enables the measuring of the ROI of the investment. The pilot project should be a project type with known metrics and is already familiar with so that the benefits of BIM can be accurately gauged and also enable the pilot team can accelerate their learning process towards determining the methodologies that should be used for future projects.

2.5.1.6 Legal Issues

As the development of BIM has become more and more important, it is worth having a look at the legal issues that may arise when working with BIM. Setting out the legal issues in the adoption of BIM will ensure that the industry can collaborate without the worry of adverse legal consequences. As BIM is expected to break down the barriers created by segmentation of a project and replace it with a collaborative working process, where all designers, engineers, contractors, sub-contractors and specialist manufacturers working on a project feed into and work on one information model or ‘federated’ models, the confusion about the precise legal effect of adopting BIM may arise. The identified legal issues are as below: (Udom, 2012)

- Contractual framework for incorporating BIM,
- Model Management and other roles,
- Intellectual property rights and data management,
- Reliance on data,
- Liabilities and
- Ownership of BIM process, risk management during model transfer and model ownership (final product)

Generally, as the consequences, the landscape of professional practice and construction will change with the introduction of BIM. The risks of using BIM are far outweighed by its benefits. The issues mentioned above should be taken into consideration when doing the amendment so that it can be incorporated by reference into the various contracts in use in the industry to minimize risks and ensure successful BIM powered projects (Udom, 2012).

2.5.1.7 Issues of Training and Learning

Implementation of new technology such as BIM technologies are costly in terms of training and changing work flows and work processes. The investment in software and hardware is typically exceeded by the training cost and initial productivity losses. Often most services providers are not willing to make such an investment unless the perceived the long term benefit to their own organization and or/if the owner subsidizes the training costs (Hammad, 2010).

2.5.1.8 Transition Team

BIM represents a new approach to building design and engineering. It is not just the implementation of new supporting technology, thus the make-up of the transition team must be paid with close attention. The formation team needs to represent the entire organization, reflecting the underlying process changes that come with BIM and it should comprised of progressive individuals who understand the big picture and represent all aspects of the firm, so that knowledge of BIM will gradually expand to all areas of the company.

2.6 Summary

This chapter had review some literature related to the research topic by defining the BIM concept, identify the industry problems and also the barriers of implementing and conclude with the review of some identified strategies to promoting BIM adoption.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Data collection is one of the most important step to success this research. In this chapter, the procedure of getting the data will be describe which from the step of deciding the research strategy, research method and until the step of doing Data analysis.

3.2 Research Strategy

There are two types of research strategies which are ‘quantitative research’ and ‘qualitative research’ (Naoum, 2007). Quantitative research is ‘objective’ in nature while Qualitative research is ‘subjective in nature (Naoum, 2007).

In this research, the data will be collected from journal articles, books, conference paper, published thesis and et cetera in order to enhance the understanding of the research.

3.3 Instrument for Data Collection

In order to achieve the aim and objectives of the research, questionnaire will be sending out by hand or via email. It is the most widely used method in conducting the survey because it is the most economy method which can offer relatively high validity of results. Except from that, it is also one of the most suitable method when a mass of information is needed and within a short period. If go for the personal interview, it might need a longer period to reach the quantity that needed for the survey.

However, there is some limitation when dealing with questionnaire survey. First, there is no guarantee that the people who complete the survey are the right person that you stated in the questionnaire form. Other than that, respondent might also answer the survey generally and also based on their knowledge or what they hear from other rather than based on their understanding towards the current industry.

3.3.1 Questionnaire Survey Design

Questionnaire survey method was adopted for this research study. A set of questionnaire which comprise of two sections was designed and distributed out in the local construction industry. All questions are structured so as to enable a logical quantitative analysis of the result.

a. **Section A:** seek to identify the Building Information Modelling (BIM) related issues which include advantages of BIM adoption, barriers for implementing BIM, consequences after Implementation and also to identify the current practice of the industry in term of individual and organizational. The composition of the questionnaire for each categories are:

Table 3. 1 Composition of Questionnaire

Grouping	No. of Items
Organization	19
Individual	11
Advantages	12
Barriers	19
Potential Factors	6
Consequences after Implementing BIM	3

Table 3. 2 Categories of Questionnaire Elements

No.	Categories					
	Organization	Individual	Advantage	Barrier	Factor	Consequences
1	√					
2-8		√				
9-19			√			
20-38				√		
39-44					√	
45-46						√
47		√				
48-49	√					
50-51		√				
52			√			
53	√					
54						√
55-60	√					
61		√				
62-70	√					

Moreover, five level rating scale methods were adopted for questions in Section A. the range of importance of each item has been ranked as shown below:

Ordinal Scale 1 to 5 in Ascending Order

1 2 3 4 5

Increasing Degree of Agreement

Each scale represents the following:

1	=	Don't Know
2	=	Strongly Disagree
3	=	Disagree
4	=	Agree
5	=	Strongly Agree

Figure 3. 1 Ordinal Scale 1 to 5

b. **Section B:** The profile of the respondent and their organization, which includes: company specialisation, size of an organization, qualification of the respondent, working experience, profession and et cetera.

3.4 Data Analysis

The data analysis that used in this research is with the help of Statistically Package Social Science – SPSS 17 software and described as below:

3.4.1 Frequency Analysis

First of all, the frequency analysis is used to represent the summary of the respondent's profile which will then be tabulated out. Basically, the respondent's profile is into three main parts: (i) Organizational, (ii) Personal and (iii) Current practice on ICT tools. By knowing the distribution of the respondents' group, the analysis can be done easily based on the ratio of it.

3.4.2 Reliability Test

Next, Reliability Test will be carried out to measure the level of acceptance of the data. Alpha Cronbach Test is used to compute the collected data. The purpose is to indicate the internal consistency reliability of the variables. When the Cronbach's alpha coefficient is greater or equal to 0.7, it indicates the strength data is consistency reliable and shall be accepted.

3.4.3 Descriptive Analysis

The basic descriptive analysis was carried out in order to found out the means and the standard deviations for the variable. The purpose is to figure out the most important variables within the identified categories. Further, the result obtained was used as the baseline for the comparison within the independent variables such as company specialisation, organization's sizes and et cetera.

3.4.4 Kruskal Wallis Test

Finally, the Kruskal – Wallis test was carried out and act as the primary test for the analysis of this research study. Kruskal – Wallis test is one of the non-parametric tests that used as the generalized form of the Mann Whitney U test. The Kruskal – Wallis test assesses the differences against the average ranks in order to determine whether or not the data are actually drawn from the same population. If it proven that the data is drawn from the same population, then the sampling distribution of the test statistic and the probability of observing the different values of the test can be tabled. However, it has one limitation. If researcher does not find a significant difference in his data while conducting the test, then he cannot say the samples are the same (James, 2009).

3.5 Research Framework

As described in Figure 3.1, these research steps provided a clear methodology framework. As such, this framework provided the proper steps to find out how to be established the research study.

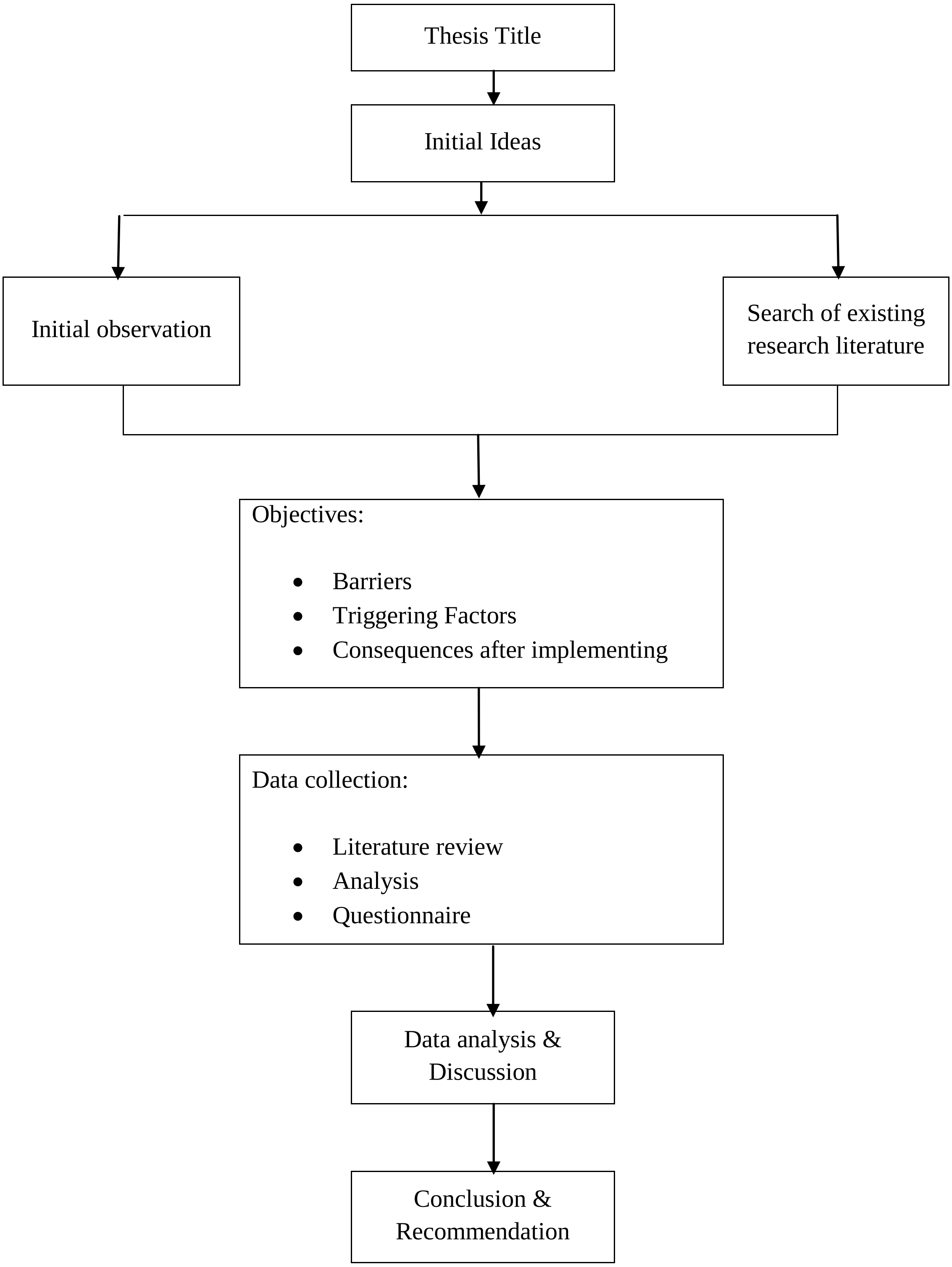

Figure 3. 2 Research Methodology Framework

3.6 Summary

In conclusion, when the data analysis has been conducted, the feasibility of this research can be proven and the opinion towards the particular issues can be summaries out and will be analysed detailed in the next chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter present and discusses the findings on Building Information Modelling (BIM) in local construction industry. The data presented are based on the outcome of the statistical analysis such as frequencies, mean rank and so on while the discussion on the results has been carried out to provide a clearer picture and understanding of the research.

4.2 Overall Survey

400 sets of questionnaire were distributed to GBI facilitator and 200 sets to the contractor firms via e-mail while 100 sets of questionnaire were distributed to consultancy firms, Architectural firms and Developer by hand.

Out of the 700 sets of questionnaire survey that was distributed, only 70 sets (10%) of responses are collected back. The distribution of respondent for the 70 sets of usable questionnaire is illustrated on Table 4.1.

Table 4. 1 Distribution of Respondents

	Via mail	**By-hand**
Distributed out	600 sets	100 sets
Collected data	13 sets	57 sets
Total collected data	70 sets (10%)	

4.3 Respondent Profile

4.3.1 Organisational

Out of the 70 sets of questionnaire, most of the respondents are QS consultancy firm (32.9%) followed by Construction firm (28.6%). Further**,** most of the respondent's organizations are involved in the Residential project (64.3%) and Social Amenities is the least (25.7%)**.** In addition, most of the respondents are from the larger organization which has more than 50 employees (43.5%) and also with organization's annual turnover more than 100 million Ringgit (39.7%).

Table 4. 2 Respondent Profile (Organisational)

Descriptions	Frequencies	Percentage (%)
A. Company Specialisation		
QS Consultancy Firm	23	32.9
Construction Firm	20	28.6
Architectural Firm	14	20.0
Engineering Firm	6	8.6
Multidisciplinary Company *	5	7.1
Property Development Company	2	2.9
B. Primary Fields		
Residential	45	64.3
Commercial	34	48.6
High Rise Building	34	48.6
Infrastructure	22	31.4
Social Amenities	18	25.7
Others	1	1.4
C. Number of Employees		
More than 50 Employees	30	43.5
Between 10 and 20 Employees	22	31.9
Between 21 and 50 Employees	9	13.0
Less than 10 Employees	8	11.6
D. Organization's Annual Turnovers		
More than RM 100,000,000	23	39.7
Between RM 200,000 and Less than RM 1,000,000	10	17.2
Between RM 1,000,000 and Less than RM 5,000,000	8	13.8
Less than RM 200,000	5	8.6
Between RM 5,000,000 and Less than RM 10,000,000	5	8.6
Between RM 10,000,000 and Less than RM 50,000,000	4	6.9
Between RM 50,000,000 and Less than RM 100,000,000	3	5.2

*Multidisciplinary company means more than one category.

4.3.2 Individual

Most of the questionnaire surveys are replied by the Quantity Surveyor (64.3%) and the majority of the respondents 1 to 5 years working experience (26.1%). Additionally, their education backgrounds are Bachelor/Degree holders (76.8%).

Table 4. 3 Respondent Profile (Individual)

Descriptions	Frequencies	Percentage (%)
A. Profession		
Quantity Surveyor	45	64.3
Project Executive	8	11.4
Architect	5	7.1
Project Manager	4	5.7
Civil/Structural Engineer	3	4.3
M&E Engineer	3	4.3
Construction Manager	1	1.4
Project/Site Engineer	1	1.4
B. Working Experiences		
1 to 2 years	18	26.1
3 to 5 years	18	26.1
Less than a year	14	20.3
More than 10 years	10	14.5
6 to 10 years	9	13.0
C. Highest Qualification		
Bachelor/Degree	53	76.8
Diploma	6	8.7
Certificate	4	5.8
Others	4	5.8
Master	2	2.9

4.3.3 Current Practice of the Industry

Table 4.4 shows that most of the organizations have the basic Microsoft office software (90.0%). Nevertheless, there is followed by 75.7% owned AutoCAD Architectural software. However, only 8.6% of respondents are using Revit

Architectural software which is same as the Primavera software are ranked third lowest.

For the ICTs tools usage, the table below shows that most of the respondents are used it on the designing task (80.0%) and is followed by measuring task (77.1%), however, most of the respondents are not using the ICTs Tools to communicate with others such as teleconferencing (31.4%).

Table 4. 4 Current Practice of the Industry

Descriptions	Frequencies	Percentage (%)
A. Software Owned in Workplace		
Microsoft Office	63	90.0
AutoCAD Architectural	53	75.7
MS Project	29	41.4
Autodesk Design Review	21	30.0
QsCAD	14	20.0
Others	13	18.6
MasterBill	10	14.3
Primavera	6	8.6
Autodesk Revit Architecture	6	8.6
Binalink BQ	2	2.9
Binalink CAD	1	1.4
B. Usage of ICTs Tools		
Designing	56	80.0
Measuring	54	77.1
Word Processing	53	75.7
E-mail Correspondence	53	75.7
Record Keeping	47	67.1
Planning and Scheduling	46	65.7
Document and Knowledge sharing (Inter-organization)	39	55.7
Document and Knowledge sharing (Intra-organization)	35	50.0
Online Social Networking	26	37.1
Web-based collaboration tools	26	37.1
Teleconferencing/Videoconferencing	22	31.4
Others	2	2.9

4.4 Questionnaire Analysis

4.4.1 Reliability Test

The questionnaire covered six issues, the details are shown in Table 4.5. The reliability test had been carried out to establish the internal consistency reliability of the collected data. The results can be accept only if the Cronbach's Alpha coefficient is greater than or equal to 0.70. The result in Table 4.5 shows that all the six issues are consistence and reliable.

Table 4. 5 Reliability Test of The Six Issues

Grouping	No. of Items	Cronbach's Alpha
Organization	19	0.830
Individual	11	0.766
Advantages	12	0.936
Barriers	19	0.940
Potential Factors	6	0.952
Consequences after Implementing BIM	3	0.745

4.4.2 Objective 2: Barriers of Implementing BIM in Local Construction Industry

Through the descriptive analysis, the lack of training and awareness on BIM application is the primary identified barriers (3.74) which follow by the cost factors such as high software cost (3.53), high hardware cost (3.43), high training cost (3.34) and et cetera. The least important barriers are the trust on the completeness and accuracy of 3D models (2.76).

Table 4. 6 Mean and Standard Deviation Table of Barriers of BIM Implementation

Barriers	Mean	Std. Deviation
Lack of training and awareness	3.74	1.073
High software cost	3.53	1.248
High hardware cost	3.43	1.234
High training cost	3.34	1.178
Upfront expenses	3.27	1.403
High coordination work	3.19	1.207
Not all information can be exchanged	3.17	1.404
Low profit	3.00	1.362
Different working practice of industry actors	3.00	1.319
Different priorities and objectives	2.99	1.257
Intellectual property and protection of copyright	2.97	1.393
Network security	2.90	1.287
Fragmented nature of industry	2.89	1.357
Difficult to ensure data integrity	2.87	1.350
Uncertain about the outcome	2.86	1.344
Temporary nature of project	2.84	1.293
Product libraries cannot be share	2.81	1.438
Lack of compatibility software	2.80	1.410
Lack of trust	2.76	1.290

When the analysis is carried out specifically based on the company's specialisation, it has proven that the views of respondents are varying on the barriers on implementing BIM (Table 4.7). From the result, the mean rank indicate the level of agreement from the respondent. The higher the score of mean rank means the more agreeable the respondent towards the element.

Table 4. 7 Result of Mean Rank and Kruskal Wallis Test of Six Issues according to Company Specialisation (df = 5)

	Chi - square	Asymp. Sig.	Architecture	Quantity Surveying	Engineering	Property Development	Construction	Multi - disciplinary
Organization	8.591	0.127	26.70	36.60	48.00	23.83	31.74	46.46
Individual	6.772	0.238	27.80	38.25	51.00	24.17	31.83	43.00
Advantages	7.228	0.204	23.20	42.23	34.50	26.50	31.35	41.11
Barriers	13.194	**0.022**	20.90	45.10	**48.00**	22.00	29.67	40.57
Potential	5.214	0.39	24.80	37.88	45.75	24.33	34.46	40.96
Consequences	12.644	**0.027**	21.00	40.53	43.25	18.75	31.78	**45.68**

The identified barriers have been confined into four elements: high training cost *(H(2) = 14.076, ρ = 0.015)* , lack of compatibility software *(H(2) = 11.448, ρ = 0.043)*, product libraries cannot be shared or used by other packages *(H(2) = 12.468, ρ = 0.029)* and network security issue *(H(2) = 16.934, ρ = 0.005)* which are statistically significant between each other. The Quantity Surveying (QS) firms are more agreeing with the four elements which is defer with the Architect's firm and Property Development Company. (Table 4.8)

Table 4. 8 Result of Mean Rank and Kruskal Wallis Test in Barriers according to Company Specialisation (df = 5)

	Chi - square	Asymp. Sig.	Architecture	Quantity Surveying	Engineering	Property Development	Construction	Multi-disciplinary
High training cost	14.076	**0.015**	17.00	**45.83**	33.50	24.33	32.63	37.14
Compatibility Software	11.448	**0.043**	22.50	**43.85**	43.75	19.17	32.39	39.14
Product libraries	12.468	**0.029**	14.40	**43.93**	42.75	31.50	30.74	40.00
Network security	16.934	**0.005**	14.10	**46.98**	42.25	32.00	28.74	38.39

Table 4.9 shows that the view of respondents are varying in terms of identified barriers *(H (2) = 12.703, ρ = 0.027).* In this comparison, the organization with less than 10 employees will consider as micro organization, large organization will be the group with more than 50 employees and the rest will consider as small-sized organization (between 10 to 20 employees) and medium-sized organization (between 21 to 50 employees) .

Table 4. 9 Result of Mean Rank and Kruskal Wallis Test According to Company Sizes (df = 3)

	Chi - square	**Asymp. Sig.**	**<10**	**10-20**	**21-50**	**>50**
Organization	5.932	0.115	42.69	33.00	47.00	30.82
Individual	5.405	0.144	46.56	30.89	42.83	32.58
Advantages	6.207	0.102	49.19	34.75	39.28	30.12
Barriers	12.703	**0.005**	**51.75**	35.61	45.22	27.02
Potential	9.248	**0.026**	**48.44**	32.64	46.50	29.70
Consequences	13.951	**0.003**	48.00	32.86	**51.94**	28.02

Whilst, the confined barriers that identified after carried out a test according to the sizes of an organization are: “The fragmented nature of construction industry” *(H (2) = 13.384, ρ = 0.004)*, “The temporary nature of construction project” *(H (2) = 11.817 ρ = 0.008)*, “The different working practices of industrial actors” *(H (2) = 18.057, ρ = 0.000)*, “The different priorities and objectives of project actors” *(H (2) = 8.174, ρ = 0.043)* , “The lack of training and awareness on BIM applications of the staff” *(H (2) = 11.907, ρ = 0.008)* and “Lack of trust on completeness and accuracy of 3D models” *(H (2) = 8.093, ρ = 0.044).* (Table 4.10)

The micro enterprises are most agreeable on all the elements except the statement that stated “BIM is difficult to adopt because lack of trust on completeness and accuracy of 3D models, the highest score for this category is achieved by the medium-sized enterprises. However, the opinion of large enterprises are defer with them except for the issue of lack of training and awareness which scored by the small-sized enterprises. (Table 4.10)

Table 4. 10 Result of Mean Rank and Kruskal Wallis Test in Term Of Barriers According to Company Sizes (df = 3)

	Chi - square	Asymp. Sig.	<10	10-20	21-50	>50
Fragmented nature	13.384	**0.004**	**53.63**	36.36	39.83	27.58
Temporary nature	11.817	**0.008**	**52.38**	32.89	44.50	29.07
Working practice	18.057	**0.000**	**57.00**	36.34	41.56	26.18
Priorities & objectives	8.174	**0.043**	**46.19**	39.41	37.83	27.93
Training & awareness	11.907	**0.008**	**50.00**	30.57	45.50	31.10
Lack of trust	8.093	**0.044**	35.81	**39.84**	45.56	28.07

Additionally, it is observed that there are some differences in terms of the respondent's opinion towards the barriers to BIM *(H (2) = 13.677, ρ = 0.033)* when the test focuses on the organization's annual turnover. However, when the following step being carried out the identified the significant barriers, the result has showed that there is no significant for the individual element. (Table 4.11)

Table 4. 11 Result of Mean Rank and Kruskal Wallis According to Organization's Annual Turnover (df = 6)

	Chi - square	Asymp. Sig.	<RM 200k	RM 200K- RM 1 mil	RM 1 mil - RM 5 mil	RM 5 mil - RM 10 mil	RM 10 mil - RM 50 mil	RM 50 mil - RM 100 mil	> RM 100 mil
Organization	5.728	0.454	42.8	24.6	32.2	31.5	26.9	18.0	29.3
Individual	3.706	0.799	35.1	26.3	33.1	24.2	30.4	19.0	30.8
Advantages	4.542	0.604	33.6	31.2	31.9	34.2	39.0	18.8	25.8
Barrier	13.677	**0.033**	40.4	32.7	**40.6**	36.3	25.0	10.2	23.7
Factors	11.084	0.086	41.9	32.7	39.4	26.9	30.9	13.7	24.4
Consequence	7.080	0.314	35.9	27.6	35.8	39.9	29.3	14.5	26.5

4.4.3 Objective 3: Potential Factors That Could Accelerate Adoption of BIM

The descriptive analysis results has shown that the most important potential factors in accelerate BIM adoption is the project's size (3.00), complexity (2.97) and delivery model (2.91) of a project. The least valuable factor is contractual requirement (2.743). (Table 4.12)

Table 4. 12 Mean and Standard Deviation Table of Potential Factors to Accelerate BIM Adoption

Potential Factors	Mean	Std. Deviation
Project is large	3.00	1.455
Project is complex	2.97	1.424
Appropriate delivery model	2.91	1.432
Contractual clause are updated	2.79	1.473
Mandatory requirement	2.79	1.392
Contractual requirement	2.74	1.337

The result has showed that the points of view of respondents are varying based on the sizes of organization. (Table 4.9)

Table 4.13 shows that the respondents' view are varying in term of the potential factors: "We will adopt BIM if the project is complex" *(H (2) = 9.443, ρ = 0.024)*, "We will adopt BIM if the project size is large" *(H (2) = 8.131, ρ = 0.043)*, "We adopt BIM because it is the contractual requirement" *(H (2) = 12.100, ρ = 0.007)* and "We adopt BIM because it is the mandatory requirement" *(H (2) = 12.030, ρ = 0.007).*

The micro enterprises are most agreeable that the size (50.00) and complexity (50.88) of a project will encourage the adoption of BIM while the medium-sized enterprises have some different opinion that adoption of BIM will be accelerate only if BIM has become the contractual (52.00) and mandatory requirement (52.83). It is noted that the result is defer from the point of view of large enterprises.

Table 4. 13 Result of Mean Rank and Kruskal Wallis Test in Term of Potential Factors to Accelerate BIM Adoption According to Company Sizes (df = 3)

	Chi - square	Asymp. Sig.	<10	10-20	21-50	>50
Project is complex	9.443	**0.024**	**50.88**	32.16	42.67	30.55
Project is large	8.131	**0.043**	**50.00**	32.57	41.89	30.72
Contractual requirement	12.100	**0.007**	42.38	34.75	**52.00**	28.12
Mandatory requirement	12.030	**0.007**	43.19	31.82	**52.83**	29.80

There is another test being carried out according to the respondents' profession. The result has proven that the opinion of the respondents do not vary based on their profession (Table 4.14). However, when the following test being carried based on the individual elements within the categories, it is found that the opinion of construction manager (69.00) is defer with the opinion of project engineer (11.50) in defining that BIM as the contractual requirement is primary factor that catalyst the BIM adoption*(H (2) = 14.3926, ρ = 0.033)*. (Table 4.15)

Table 4. 14 Kruskal Wallis Test According to Profession

	Organization	Individual	Advantages	Barriers	Potential	Consequences
Chi-Square	6.716	5.002	6.166	8.321	9.596	9.192
df	7	7	7	7	7	7
Asymp. Sig.	0.459	0.66	0.52	0.305	0.213	0.239

Table 4. 15 Result of Mean Rank and Kruskal Wallis Test (df = 7)

	Chi - square	Asymp. Sig.	Architecture	Civil/Structural Engineer	M&E Engineer	QS	Project Executive	Construction Manager	Project Manager	Project/Site Engineer
Contractual Requirement	14.393	**0.045**	16.20	34.00	19.33	34.47	40.13	**69.00**	50.38	11.50

4.4.4 Objective 4: Consequences If BIM Has Been Adopted

The mean ranks of the consequences category are as follow: include the relevant cost of BIM in their bid (3.03), follows by withdrawing from the tendering if BIM is mandated (2.51). (Table 4.16)

Table 4. 16 Mean and Standard Deviation Table of Consequences if BIM Has Been Adopted

Consequences	Mean	Std. Deviation
Include the cost of BIM	3.029	1.484
Not offer bit if BIM is mandated	2.514	1.338

The opinions of the respondents are varying in term of the consequences according to their company specialisation (Table 4.7). The scores are: “We will not offer a bid if BIM is mandated” *($H (2) = 11.897$ $\rho = 0.036$)* and “We will include the relevant cost in our bid if BIM is mandated” *($H (2) = 12.466$, $\rho = 0.029$).* (Table 4.15)

Table 4.17 shows that the Multidisciplinary firms are agreed that they either will include the relevant cost of BIM in their bid if it is mandated (43.75) or withdraw from the tendering process (44.79). However, the Architect disagrees with their points of views (19.00) that to withdraw from the bidding process whilst the Property Development Company disagrees that the BIM relevant cost should be included in the bidding price if it is mandated (17.50).

Table 4. 17 Result of Mean Rank and Kruskal Wallis Test in Consequences if BIM Has Been Adopted according to Company Specialisation (df = 5)

	Chi - square	Asymp. Sig.	Architecture	Quantity Surveying	Engineering	Property Development	Construction	Multi-disciplinary
Not offer bid if BIM is mandated	11.897	**0.036**	19.00	41.60	35.25	21.00	32.57	**43.75**
Include the cost of BIM	12.466	**0.029**	22.40	39.08	**47.00**	17.50	33.28	44.79

Table 4.18 shows that the point of view of respondents towards the consequences are varying: “We will not offer a bid if BIM is mandated” *(H (2) = 15.791, ρ = 0.001)* and “We will include the relevant cost in our bid if BIM is mandated” *(H (2) = 14.621, ρ = 0.002).*

The medium-sized enterprises stated that “We will not offer a bid if BIM is mandated” (52.28) and the micro enterprises agree that the relevant cost of BIM application will be included in their bid if BIM is mandated (56.00). However, it is defer with the opinion of large enterprises. (Table 4.6)

Table 4. 18 Result of Mean Rank and Kruskal Wallis Test in Term of Potential Factors to Accelerate BIM Adoption According to Company Sizes (df = 3)

	Chi - square	**Asymp. Sig.**	**<10**	**10-20**	**21-50**	**>50**
Not offer bid if BIM is mandated	15.791	**0.001**	49.13	31.84	**52.28**	28.37
Include cost of BIM	14.621	**0.002**	**56.00**	32.27	42.83	29.05

4.4.5 Others Descriptive Analysis

4.4.5.1 Current Practice of Organization

Table 4.10 shows that majority of the respondents have internet connection in their office (4.07) and job-site (3.54), follow by the current practice that only review paper-based drawing (3.46). There are minority of them have organization (2.67) and technical infrastructure (2.66) to support BIM. (Table 4.19).

Table 4. 19 Mean and Standard Deviation Table of Current Practice (Organisational)

Current Practice	Mean	Std. Deviation
Have internet connection in office	4.07	0.873
Have internet connection at job site	3.54	1.176
Only review paper-based drawing	3.46	1.151
Positive organization culture of change	3.37	1.206
Strict on sign document	3.36	1.168
Encounter problem on software interoperability	3.33	1.188
Limited alignment	3.19	1.705
Data exchanged across department is limited to 2D	3.10	1.131
Data exchanged across organization is limited to 2D	3.10	1.079
Strong leadership	3.09	1.349
Clients have positive culture	2.96	1.290
Data exchanged across department is limited to 3D	2.90	1.118
Data exchanged across organization is limited to 3D	2.89	1.057
My boss expect me to know	2.89	1.123
Easy to change the standard working practice	2.84	1.125
Prequalification'	2.80	1.400
Expose to lawsuit	2.74	1.380
Prequalification reduce competition and raise price	2.73	1.340
Have organization infrastructure to support BIM	2.67	1.282
Have technical infrastructure to support BIM	2.66	1.295

4.4.5.2 Current Practice of an Individual

Table 4.11 shows that in the current construction industry, majority of the workers insist to receive paper based document and drawing (3.47) and they are comfortable with the traditional way of working practice (3.26) especially in situation of high time pressure (3.23). Minority of them are clear about who is going to make change in the organization (2.59). (Table 4.20)

Table 4. 20 Mean and Standard Deviation Table of Current Practice (Individual)

Current Practice	Mean	Std. Deviation
Only received paper based document and drawing	3.49	0.974
Comfortable with the traditional way	3.26	1.200
Comfortable with the traditional way especially in situation of High time pressure	3.23	1.182
Clear about the information has to be communicate to whom and in what form	3.01	1.148
BIM enhance personal job performance	2.96	1.449
Don't have time to learn	2.86	1.011
I am clear about BIM	2.80	1.111
Mandate only the outcomes of the use of ICT	2.73	1.372
I have the capability to operate	2.73	1.215
I have attended training	2.64	1.050
I am clear about who is going to make change	2.59	1.335

The point of view of respondents is varying based on their highest education qualification (Table 4.21).

Table 4. 21 Result of Mean Rank and Kruskal Wallis According to the Education Qualification (df = 4)

	Chi - square	Asymp. Sig.	Master	Bachelor/ Degree	Diploma	Certificate	Others
Organization	3.849	0.427	36.25	32.75	42.25	38.25	50.13
Individual	10.741	**0.030**	49.50	31.20	45.08	38.13	**59.88**
Advantages	5.61	0.230	46.75	32.11	47.25	36.50	47.50
Barriers	2.683	0.612	27.25	33.39	40.75	40.38	46.25
Potential	7.658	0.105	33.75	31.64	49.92	45.63	47.13
Consequences	4.588	0.332	47.50	32.38	39.33	43.50	48.50

The result of Kruskal Wallis Test shows that there are statistically significant between the compare groups for the "Individual" category *(H (2) = 10.741, ρ = 0.030)* with the elements: "I have the capabilities to operate BIM system" *(H (2) = 12.027, ρ = 0.017)*, "I am clear about the BIM application" *(H (2) = 11.763, ρ = 0.019)* and "BIM enhances my personal job performance" *(H (2) = 12.130, ρ = 0.016).*

For the groups with others qualification, most of them said that they have the capability to operate BIM system (60.50) while for the Mater holders, they are clear about the BIM application (63.75) and both the Master holders and others qualification group are agreed that BIM can enhances personal job performance (57.25). (Table 4.22)

On the other sides, least of the degree and certificate holders have the capability to operate BIM application (31.74) and most of the diploma holders are unclear with the BIM application (32.00). Additionally, least of the certificate holders agree that BIM can enhances personal job performance (31.75). (Table 4.22)

Table 4. 22 Result of Mean Rank and Kruskal Wallis of Current Practice (Individual) According to the Education Qualification (df = 4)

	Chi - square	Asymp. Sig.	Master	Bachelor/ Degree	Diploma	Certificate	Others
Capability to operate BIM	12.027	**0.017**	58.00	31.74	43.33	31.75	60.50
Clear about BIM	11.763	**0.019**	63.75	32.58	32.00	33.25	59.00
Enhance personal performance	12.130	**0.016**	57.25	33.70	36.92	16.00	57.25

4.4.5.3 Benefits of BIM Application

The primary advantages of the BIM application are to enhance organization's performance (3.64), follows by enhancing organization's image (3.60) and to compete with competitor (3.29). The least agreeable benefit is client expect BIM to liaise with other project actors (2.77). (Table 4.23)

Table 4. 23 Mean and Standard Deviation Table of Benefits of BIM Application

Advantages	Mean	Std. Deviation
BIM enhance organization's performance	3.64	1.297
BIM enhance organization's image	3.60	1.267
Adopt BIM to compete with competitor	3.29	1.309
Adopt BIM to fulfil "green commitment"	3.26	1.247
Encourage better collaboration	3.13	1.474
Provide more transparency	3.11	1.399
Align working practice of construction industry	3.09	1.391
Align the project's priorities and objective	3.04	1.345
Client expect to have BIM	2.89	1.246
Align working practice of organization	2.83	1.372
Client expect BIM to liaise with other actors	2.77	1.218

4.4.6 Others Kruskal Wallis Test

4.4.6.1 Comparison Based on Working Experience

There are no significant elements between the comparison group *($\rho<0.05$)***.** (Table 4.24)

Table 4. 24 Kruskal Wallis Test on the Six Issues According to Working Experience

	Organization	**Individual**	**Advantages**	**Barrier**	**Potential**	**Consequences**
Chi-Square	7.742	1.898	0.698	1.742	5.261	1.871
df	4	4	4	4	4	4
Asymp. Sig.	0.101	0.754	0.952	0.783	0.262	0.76

However there are some individual elements that are statically significant: "The low profit/fees discourage our organization to adopt BIM" *($H(2) = 11.022$, $\rho = 0.026$)*, "We will include the relevant cost in our bid if BIM is mandated" *($H(2) = 9.530$, $\rho = 0.049$)*, "We always encounter problem on software interoperability when communicate and exchange information digitally among different organizations" *($H(2) = 14.732$, $\rho = 0.005$)*, "Our data exchange across the organization is limited to 2D drawings*" ($H(2) = 10.282$, $\rho = 0.036$)* and "My organization has the organizational infrastructure to support the BIM system*($H(2) = 9.468$, $\rho = 0.050$).*

For the category of working experience more than 10 years, they are most agreeing that the low profit/fees are the barrier to implement BIM. They also stated that they have faced the interoperability problem when exchanging information and communicate across organization. Further, their data exchanged across the organization is limited to 2D drawings. However, for the element that stated "We will include the relevant cost in our bid if BIM is mandated" is achieved by the category of 6 to 10 years working experience while majority of the category of 1 to

2 years experiences have the same opinion that their organization has the organizational infrastructure to support BIM.

For the lowest mean rank, most of the elements are scored by the category of less than a year experiences except the statement that stated “We will include the relevant cost in our bid if BIM is mandated” which have achieved by the category of 3 to 5 years working experiences.

Table 4. 25 Result of Mean Rank and Kruskal Wallis on Six Issues According to Working Experience (df = 4)

	Chi square	Asymp. Sig.	<1 Year	1-2 Years	3-5 Years	6-10 Years	>10 Years
Low profit	11.022	**0.026**	**27.86**	36.00	28.86	38.56	**51.05**
Include cost of BIM	9.530	**0.049**	36.71	30.89	**27.14**	**47.11**	43.25
Software inter-operability	14.732	**0.005**	**23.57**	38.42	28.92	43.11	**48.50**
Data exchanged (Inter)	10.282	**0.036**	**29.64**	42.39	28.33	29.78	**45.90**
Supported Infrastructure	9.468	**0.050**	**25.25**	**43.94**	29.75	38.61	38.75

4.5 Discussion

4.5.1 Objective 1: Current Practice and Awareness of the Local Construction Industry

Generally, the construction professionals are aware about the benefits that brought by BIM towards an organization such as BIM can enhance organization's performance and image and enable them to compete with competitor, fulfil the 'green commitment' and et cetera which also can act as the catalyst for the BIM adoption. However, they are least aware about the function of the BIM in term of its interoperability. This might become one of the reasons that adoption of BIM in local industry still slow and does not aware by majority of the construction professional.

However, it can be observed that, the usage level of the ICT tools in local industry is high especially with the AutoCAD application. This might due to the popularity of the application within the industry and make it more users friendly. This might be a good sign for emerging BIM to the industry as they are assume to be readily in accepting new technology (Section 2.5.1).

Besides that, from the analysis result, it shows that qualification level of a respondent and their understanding towards the BIM application are equal which means that, the higher their qualification, the more understandable they are towards the application. This can be concluded with their exposure towards the new information as they are dealing with the IT tools more often as the need to retrieve information for their studies.

4.5.2 Objective 2: Barriers of Implementing BIM in Local Construction Industry

The views on barriers in implementing BIM are defer between the companies involve with different specialisation and varying in organization size.

(a) Company Specialisation

From the previous analysis, it is observed that, the Architects' points of views are deferring with the Quantity Surveying firms (Table 4.8). This can be explained according to the different role ad duties of the construction professionals (Section 2.3). For a Quantity Surveying firm that providing services such as cost control, contract administration and et cetera, their orientation are more towards the client's satisfaction. in order to carried their work professionally, they have to concern about the issue that will affecting the client's satisfaction such as the dispute issue that might rise up is the net work security is insecure while implementing BIM and the information cannot be retrieved from the product library that due to the lack of compatible software.

However, it should be noted that, no commercially available software application or technology platform is capable of containing all of the information created about a building throughout its useful life and making it possible to appropriate stakeholders in real time on demand (Section 2.5.1.1). A proper strategic may be come out to resolve this issue during the BIM deployment.

(b)Sizes of Organization

It is noted that the opinion of micro enterprises are defer with larger enterprises. The current practice of micro-sized enterprise in the construction industry in acquiring new technologies with the aim of transforming themselves into world-class companies, their needs and requirements seem to be common. Except from that, smaller enterprises have lesser tendency to use ICT for strategic purpose for sharing information as compared to larger enterprise as they have different priorities and objectives (Section 2.2).

However, it is also observed that the opinion of a small-sized enterprises are also defer with the micro enterprises although they have a more similar characteristic in term of financial, environment and management especially on the issue related to training and awareness of the staff towards the BIM application. This may conclude that the due to the insufficient human resources that resist them from forming a transition team to deal with it.

Furthermore, the lack of trust on completeness and accuracy of 3D models is the identified barrier for the medium-sized enterprises. This is due to the organization's goal that to sustain competition and also long term growth of the business in order to meet the customer/clients' needs. They need a more compatible and trustable software to align with their business strategy in order to achieved higher rate for returns on investment (Section 2.5.1.4). Therefore, the completeness and accuracy of a model is important for them.

(c)Organization's Annual Turnover

Lastly, for the classification of organization that based on annual turnover, there is no significance elements that found within the barriers category. The result only shows that the opinion of respondents towards the "Barriers" category are defer when analysis was carried out.

4.5.3 Objective 3: Potential Factors That Could Accelerate Adoption of BIM

For this analysis, the classification of organization will be micro enterprise (less than 10 employees), small-sized enterprise (between 10 to 20 employees), medium-sized enterprise (between 21 to 50 employees) and large-sized enterprise (more than 50 employees).

(a)Sizes of Organization

Based on the analysis results, nature of a project is crucial in accelerate BIM adoption especially for smaller organization as they have less human resources if there is a larger project on hand. For a large and complex project, there is a flow of vast information from the design phase till the end of the project. It is essential to have manageable software to resolve the interoperability issue incurred throughout the process. As BIM has a broad range of applications that right cross the design, construction and operation process (Section 2.4.1) which provide the benefits that help to solve the relevant problems (Section 2.4.2) and thus make it the first choice when there is a large and complex project has initiated with the needs stated above.

For medium-sized enterprises, it is observed that customer satisfaction is favoured as a niche performance criterion for the strategic use of BIM. It also can conclude that part of their driving forces is globalization and technology. In order to sustain competition as well as long-term growth of the business, they were more decisive in adopting new technologies so that higher returns on investment can be achieved by align their business strategic with the technology (Section 2.5.1.4).

4.5.4 Objective 4: Consequences If BIM Has Been Adopted

It is observed that the key problems in adopting BIM tended to point to cost of investments.

(a)Company Specialisation

For the design team (Architect), technical competency is key to the designing and drafting practice, and the increased precision derived from using computer-aided applications is becoming one of the main business focuses (Section 2.3.2). Therefore, they were disagreed with the withdrawal of the contractor from the bidding process once BIM has become mandatory requirement. While form the clients' point of views, the advantages of adopting BIM is seem from other countries' case studies but if the bidders have include the cost of BIM implementation when pricing, the project's cost will be increased and thus decreased their profit margin. In order to safeguard their profits, they are opposed with the bidders' opinion that to share the implication cost. It is same for the construction teams also. They are uncertain with the outcome of new technology and also the risks they will exposed to, thus, they have to protect their rights during the construction process.

(b)Sizes of Organization

It is noted that result indicated that the perceived consequences are contrary with results found according to the factors that act as catalyst towards the BIM adoption. the medium-sized enterprises indicated that they will adopt the BIM if it is contractual or mandatory requirement in previous analysis but the result for consequences shows that they will not offer a bid if BIM is mandated. Therefore, it is noted that, not necessary the medium-sized enterprises will adopt BIM in order to meet the client's satisfaction. Sometime, there are others factors that need take into consideration in order to emerging a new technology to their organization.

4.5.5 Summary

Although there are only three elements that have discussed in this section which have been proven there is statistically significant based on their comparison group: barriers to BIM implementation, potential factors that could accelerate BIM adoption and the consequences if BIM is being mandated. However, this does not mean that the opinion of the respondents towards others issue is similar or the other issue is not important. This might incurred due to the number of respondents that adapted to the research survey. Additionally, from the result of descriptive analysis, it is noted that the perceived benefits of the respondents are more towards organization improvement such as enhance performance, image and et cetera (Table 4.21).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The aim of this research is to investigate the issues of BIM adoption in local construction industry. This chapter will conclude the whole research by reviewing the research objectives and discuss the implication of this study which followed by a reflection of the limitations of this research and recommendations for future research.

5.2 Summary of Findings

This research found that the adoption of AutoCAD is popular within the industry and the high level of ICT adoption has make industry more readily in adopting new technologies (Objective 1). Further, this research also found that the identified barriers can be group into three main categories: people, financial and environment oriented (Objective 2) which has been reflected on the potential factors that affect the decision making of the industry in adopting BIM (Objective 3) and perceived consequences if BIM has been implemented (Objective 4).

5.2.1 Objective 1: Current Practice and Awareness towards New Technologies

This study identified that majority of the construction industry are using AutoCAD application that may due to its popularity or available competent users against any other available software. This result indicated that the respondent are ready to accept new technology as stated in chapter 2, the organization with high level of ICT usage will more readily in adopt new technologies. Thus, it can conclude that, the local construction industry is ready in accepting the emerging of new technologies.

5.2.2 Objective 2: Barriers of Implementing BIM

Generally, the identified barriers based on descriptive analysis are more towards the financial issues which include: software and hardware cost, training cost and upfront expenses. Additionally, lack of training and awareness which belong to the factors under group of environmental is ranked as the most important issue in implementing BIM.

However, the identified barriers are different when the analysis is carried out in the more detail way which is restricted based on role organization sizes and specialization. That is: high training cost incurred, lack of compatibility software, product libraries cannot be shared or used by other package and network security issue are identified by the Quantity Surveying firm but it is defer with the architect's opinion which does not consider those elements as the barriers for BIM implementation.

While the agreed barriers identified by smaller organization are: fragmented nature of construction industry, temporary nature of construction project, different working practices of industrial actors, different priorities and objectives of project actors, lack of training and awareness on BIM applications of staffs and lack of trust on completeness and accuracy of 3D models. It is observed that that factors that affecting the decision of an organization to adopt BIM more towards the people and project oriented. People are the key factors in determining the adoption of BIM. Therefore, it can be conclude that, people and capital are always the key factors in affecting the adoption of new technology

Moreover, it also should be noted that there is no perfect software application that is capable of containing all of the information created about the whole life cycle of a building. BIM is a specialized tool that designed to solve this problem although there is some imperfectness due to the following legal issues incurred, but it can be resolve by doing some amendment on the current contract in used or develop some new terms in protecting the BIM user as it becoming more and more important in the future.

5.2.3 Objective 3: Potential Factors that Could Accelerate BIM Adoption

The potential factors that could accelerate the BIM adoption in local construction industry have been identified: Complexity of project, Sizes of project, adoption of BIM is the contractual requirement, and mandatory requirement.

It is observed that, the identified factors are a reflection of the barriers identified through the survey. The mean of complexity and sizes of a project is actually related to the capital required and also the coordination needed within the project. When there is a complex and large project, the flows of the mass information required a better coordinated software to manage it so that the percentage of errors or disruption occurred can be minimized. Other than that, in order to be more competitive in the market or in order to get the project, the adoption of BIM also will be accelerated. However, it should be noted that transitioning to BIM is not an easy job and it needs a long time preparation to successfully emerging into the local industry. Others than the factors mentioned previously, the perceived value from the users also have to take into consideration. The trust towards the application have to build as people is one of the key factors contribute to the BIM implementation.

5.2.4 Objective 4: Consequences if Implement BIM

There are two consequences after mandating BIM have been identified through the analysis: not offer a bid or include the relevant cost of implement BIM in their bid if BIM is mandated.

In order to promote implementation of BIM application, it is necessary to consider both from the clients and also the contractors' point of view. The uncertainty of the financial risk that caused by the technology changes should be bear by the both parties but not transfer to the contractors as financial capability is one of the identified barriers in implementing BIM. The sharing of the implementation cost by the client is essential in these cases.

5.3 Implications

The results of this research have reinforced the findings of previous studies in terms of the identified barriers on implementing BIM. Thus, the government can draw their attention on that specified issues and used it as the baseline in drafting the strategies to promote the BIM application. For example, government can adopt the success factors of others countries as benchmarking in introducing BIM to the local industry such as implementation of BIM implementation guideline, provide pilot study and et cetera.

For the academic and researcher, they can develop some framework for the implementation that suits our local construction industry and practices by referring to other countries. Furthermore, they also can refer to International Alliance for Interoperability (IAI) standards as most of the countries such as US is developed their framework based on the IAI's standard.

5.4 Research Limitations

Basically, there are some limitations are met or had to be taken into consideration such as distribution of respondents in questionnaire survey,

In this research, the collection of data primary was conducted using questionnaire survey. Basically, questionnaire survey forms can only give reasonably realistic results when high response rate is achieved. Although with a result of 70 respondents, the results and analysis of this research could still be considered as accurate and acceptable.

However, it is essential to have more balanced distribution of respondents from the categories of this survey such as the company specialization and profession of respondent. The unbalanced distribution of respondents which more focus on the quantity surveyor will make the result and analysis of this research bias towards the opinion of them. Thus, the result of the comparison will become unfair or inaccurate. For example, the number of respondent that come from engineering firm are only two person which is under the minimum requirement of the chi-square test that is at least five people.

Except from that, respondent level of understanding BIM implementation need to be balanced by top and middle level management as they are the group that clear about the effect of the innovation and more understand about the operation of an organization. Besides, their experience in this industry also will make their answer or point of view more reliable and thus the analysis also.

5.5 Recommendations for Further Research Study

The subject on Building Information Modeling (BIM) is continuously under study. Based on this study, the following could be possible area for further research that may also be beneficial to the industry:

- To propose alternatives based on the identified barriers in promoting adoption of BIM.
- To evaluate the differences between BIM based Project and Non BIM based project through some solid case studies.
- To conduct a similar research towards the reason and perception of top and middle level management on BIM.
- To develop a more appropriate system in solving interoperability issue in the context of the local construction industry.

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APPENDICES

APPENDIX A: Survey Questionnaire