CHALLENGES AND BARRIERS OF BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION IN CONSTRUCTION INDUSTRY

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Thesis submitted in fulfillment of the requirements
for the award of the
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To my beloved parents, Hamzah Ahmad and Rodiah Abd Majid.

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ABSTRAK

Building Information Modelling (BIM) adalah proses berasaskan model intelektual yang memberikan wawasan untuk mewujudkan dan mengurus projek bangunan dan infrastruktur dengan lebih pantas, lebih ekonomik dan kurang kesan terhadap alam sekitar. BIM ditakrifkan sebagai teknologi pemodelan dan set yang berkaitan proses untuk menghasilkan, berkomunikasi, menganalisis dan model bangunan sepanjang kitaran hayat keseluruhan projek. Walaupun terdapat manfaat yang diperoleh daripada penggunaan BIM, industri pembinaan tempatan masih enggan menggunakan teknologi dalam penyampaian perkhidmatannya. Objektif kajian ini adalah untuk mengenal pasti jenis cabaran dalam mengaplikasikan BIM di dalam sector pembinaan melalui kajian bacaan, merangka soalan soal selidik mengenai cabaran dan halangan untuk mengaplikasikan BIM dan juga mengkaji kesan cabaran kepada hasil BIM sekiranya BIM diguna pakai dalam industri pembinaan tempatan. Kajian soal selidik telah diedarkan dalam sektor pembinaan, perunding dan firma seni bina di kawasan Lembah Klang. Kaedah pengumpulan data adalah dengan menggunakan soal selidik dan juga temubual ringkas. Kesimpulan utama diambil daripada kajian ini adalah tahap yang tinggi penggunaan ICT di kalangan profesional pembinaan telah menjadikan industri yang lebih mudah dalam BIM muncul dan halangan yang dikenal pasti boleh terbatas kepada tiga kategori utama iaitu di kalangan individu, teknologi serta proses. Kesimpulan yang diambil dari kajian ini adalah kos, kekurangan dalam bekerjasama dalam sesebuah projek dan panduan permodelan serta sifat pentigkan urusan masing-masing merupakan cabaran dan halangan paling besar dalam pelaksanaan BIM dalam industri pembinaan.

ABSTRACT

Building Information Modelling (BIM) is an intelligent model-based process that provides insight for creating and managing building and infrastructure projects faster, more economically and with less environmental impact. It also represents the process of development and use of a computer generated model to simulate the planning, design, construction and operation of a facility. 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 is to identify the types of challenges from relevant literature review related to BIM, to design the questionnaire on the challenges and barriers during the implementation of BIM and to analyse the effect of challenges to the outcome of BIM. The survey questionnaires were distributed in the construction field, consultant firm and architecture firm within Klang Valley. The method of data collection is by questionnaire and also simple interview. The main conclusion drawn from the study are cost, lack of collaborative work processes and modelling standards and fragmented nature are the most largest challenges and barriers in the implementation of BIM in construction industry.

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LIST OF ABBREVIATIONS

AEC	Architecture, Engineering, Construction
AGC	Associated General Constructors
AI	Average Index
AIA	American Institute of Architects
BAS	Building Automation System
BCSs	Biosafety Cabinets
BIM	Building Information Modelling
CAD	Computer Aided Design
CADD	Computer Aided Drafting and Design
CAM	Computer Aided Manufacturing
CIDB	Construction Industry Development Board
CMM	Capability Maturity Model
CNC	Computer Numerical Control
COBie	Construction Operations Building Information Exchange
CPM	Critical Path Method
ICT	Information and Communication Technology
IPD	Integrated Project Delivery
IT	IT Information Technology
MEP	Mechanical, Electrical, Plumbing
NBIMS	National Building Information Modelling Standards
O&M	Operation & Maintenance
PrM	Production Manager

RFID	Radio Frequency Identification
ROl	Return on Investment
2D	Two Dimensional: x,y
3D	Three Dimensional: x,y,z
4D	Four Dimensional
5D	Five Dimensional

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Building Information Modelling (BIM) is an intelligent model-based process that provides insight for creating and managing building and infrastructure projects faster, more economically and with less environmental impact. It also represents the process of development and use of a computer generated model to simulate the planning, design, construction and operation of a facility (Arayici, 2009).

The Building Information Model is primarily a three dimensional digital representation of a building and its intrinsic characteristics. It is made of intelligent building components which includes data attributes and parametric rules for each object. For instance, a door of certain material and dimension is parametrically related and hosted by a wall. Furthermore, BIM provides consistent and coordinated views and representations of the digital model including reliable data for each view.

This saves a lot of designer's time since each view is coordinated through the built-in intelligence of the model. According to the National BIM Standard, Building Information Model is "a digital representation of physical and functional characteristics of a. facility and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle; defined as existing from earliest conception to demolition".

Construction industry is moving rapidly toward 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 (Arayici, 2009).

However, the performance of ICT towards the industry is still under privileged. It might be due to the different types of software used by the participants of the industry, the amount of the redundant information and the manual transfer of information (McGraw-Hill, 2008).

To solve, this problem, Building Information Modelling (BIM) has been introduces 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). Although the adoption of BIM is expanding within the industry and it have been beneficial to 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 (McGraw-Hill, 2008).

1.2 PROBLEM STATEMENT

The productivity and economic benefits of BIM to AEC industry are widely acknowledges and increasingly well understood. Further, the technology to implement BIM is readily available and rapidly maturing. Yet, the adoption of BIM is much slower than anticipated (Jung, Y., & Joo, M, 2011).

The researchers and practitioners have to develop suitable solutions to overcome these challenges and other associated risks. There are two main reasons; technical and managerial that cause BIM adoption is much slower than anticipated (Kacprzyk, Z, 2014).

The major drawback of technical and managerial challenges needs to be identify, synthesize and discuss. It is expected that the use of BIM will continue to increase in the AEC 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 (Kiviniemi, A, 2013).

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 RESEARCH OBJECTIVES

The following is the research objectives that guide me throughout the study:

1.3.1 To identify the types of challenges from relevant literature review related to BIM.

1.3.2 To design the questionnaire on the challenges and barriers during the implementation of BIM.

1.3.3 To analyse the effect of challenges to the outcome of BIM.

1.4 SCOPE OF STUDY

This study focused on the participants of the construction industry generally consists of Consultants, Engineers and Contractors. The respondents will complete the questionnaire and give their opinions towards the challenges of Building Information Modelling (BIM) in project implementation and also project related issues. In addition, the study will focus on the construction industry, consultant firm and architecture firm located within Klang Valley area.

1.5 SIGNIFICANCE OF STUDY

Construction industry is a one of the main factors that leading a country's economy. It is undeniable that the usage of BIM in project implementation in construction industry brings benefits, but there are barriers that affect the implementation of BIM in construction industry. In order to make sure that BIM can be implemented, we have to find out the challenges that influence the BIM implementation. By doing this research, current challenges of BIM in project implementation can be recognized. Besides, this may also help the Engineering Design Consultants and Contractors so that the solutions to overcome these can be found. Lastly, tangible benefits of BIM can be enjoyed by the construction industry.

1.6 THESIS STRUCTURE

In this study, there will be five chapter that will be covered which are:

1.6.1 Chapter 1: This chapter covers the background of the study, problem statement, research objectives, scope of the study and significance of the study.

1.6.2 Chapter 2: This chapter covers the basic information about Building Information Modelling (BIM) which includes the concept of BIM, the challenges and barriers for the implementation of BIM and also the benefits of BIM.

1.6.3 Chapter 3: This chapter covers the methods that are being used in order to collect the needed data to be analyse that related to the study.

1.6.4 Chapter 4: 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 analysis while the discussion on the results has been carried out to provide a clearer picture and understanding of the research.

1.6.5 Chapter 5: This chapter covers the conclusion and recommendation for the research.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter covers the basic information about Building Information Modelling (BIM) which includes the concept of BIM, the barriers to implementation such as legal issues, interoperability, major stakeholders' support, resistant to change, and also the benefits of BIM such as reduces conflicts and changes during construction, clash detection and reduce risk mitigation.

2.2 BUILDING INFORMATION MODELLING

Earlier, CAD systems were used to produce drawings and three-dimensional images. Now the focus has shifted to the data itself. BIM has following components: those with data, those that build (with intelligent digital representations), those with consistent and non-redundant data, and those with coordinated data. All of these enable the architects to catch and avoid the costly mistakes and in a way, virtually try the building before incurring the huge expense of building it in real-time (McGraw-Hill Construction, 2008).

BIM helps construct a virtual yet accurate model of the building in the digital world before raising it in the physical world. This building model supports construction, fabrication and procurement activities and, thus, can be used for feasibility studies, conceptual design, more accurate estimating, relative detailing, easier coordination, etc. by the architectural firm; and also for construction planning, logistics, operation, etc. by the other members of the team (McGraw-Hill Construction, 2008). Another use the architect can employ BIM for is to study the building's performance, such as solar studies, energy usage, green building analysis, construction costs, sequencing of construction, etc.

BIM allows easier coordination of different software and project personnel, which leads to improved productivity, communication and quality control (McGraw-Hill Construction, 2008). It transforms how buildings are built, how they look and how they function - adding intelligence, to the buildings. The powerful 3D model helps visualize, present and create architectural documents. It helps save time and reduces errors as design changes are automatically coordinated throughout the entire model. Not only are the building elements represented as 3D objects, but it also accommodates associated information about each element.

The concurrent information is kept up-to-date and digitally accessible, giving clear overall vision and ability to make better decisions faster. Using BIM technology, all phases of design, scope, documentation, cost information and scheduling can be better coordinated, leading to better reliable quality and allowing for higher profitability for the project team. Changes can be made without laborious, low-value coordination and manual rechecking. Hence, the architectural industry in US ends up saving time and money, making fewer errors, getting greater productivity, higher quality of work and repeat business opportunities (AlA Knowledge Resources Staff, 2008).

Architectural, mechanical and structural elements are most likely to be modelled in BIM. In the US, architects are the heaviest users of BIM, with 43% using it on more than 60% of their projects, and it is observed that BIM has a very positive impact on architects' businesses (McGraw-Hill Construction, 2008). In India, the client enters into agreement with an architect defining their scope of work, responsibilities, functions, fees and mode of payment. Once the architect has completed the design, he prepares working drawings, specifications and schedule of quantities sufficient to prepare estimate of cost and bid documents. He also invites, receives, analyses tenders and advises client on appointment of contractors (Council of Architecture of India). Hence, in determining whether BIM should be used on a project, architects are considered the primary drivers of BIM use among all build team members, making them the top decision makers. As a matter of fact, BIM was initially developed with a focus on the design world.

BIM reduces risk of errors' occurrence in the design process (Bansal, 2009). Human errors are caught and corrected during the design process itself due to the extended coordination and communication across the entire project team. BIM improves design decision making, prediction of performance, cost estimation and construction planning with automatic document coordination and clearer project communication.

Quantity take off, scheduling and estimating are the top most popular tools used in conjunction with the integrated modelling data (Tulke, Nour and Beucke, 2008). BIM enables quantities of materials to be tracked throughout the project, hence, allowing quantity take offs and cost estimates to be more accurate and reliable than those prepared using conventional methods. Less field staff can do the work of a typical larger staff if contractors employ BIM on the construction site too.

2.3 NATURE OF CONSTRUCTION INDUSTRY

The construction industry has lagged behind other industries in accepting the benefits of adopting Information Communication Technology (ICT). In 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 (Bansal, 2009).

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 (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.

2.4 ROLES OF CONSTRUCTION PROFESSIONALS

Building construction requires many workers and many trades. From the perspective of realizing 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 (Haron, 2013).

2.4.1 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.

2.4.2 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 (Haron, 2013).

2.4.3 Engineer

The scope of work of engineers involves planning and execution of the designs from transportation, site development, and hydraulic environmental, structural and geo technical engineers. The main part of engineers' job description is analysing report which includes the analysis of maps, drawings, blueprints, aerial photography, topographical information, calculation of the building loads and analyses 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 (Haron, 2013).

2.4.4 Contractor/ Builder

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 (Haron, 2013).

2.4.5 Quantity Surveyor

Quantity Surveyor is the person who manages and control costs within construction projects and may involve 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, labor, 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 (Haron, 2013).

2.5 THE CONCEPT OF BIM

Building Information Modelling (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 analyse to generate information that can be used to make decisions and to improve the process of delivering the facility (Howard, 2008).

While, Stelth (2009) 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

- 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 modelling 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 (Post, 2010). 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 (Stelth , 2009).

2.5.1 Function of BIM

According to Larson (2008), BIM has a broad range of application, right cross the design, construction and operation process. These BIM function 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 modelling 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 modelling, 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, managing metadata and linking multiple databases (model & text file).

2.5.2 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 (Larson, 2008). While when look into the individual elements, the main benefits that drive the deployment are: (Kymmell, 2008)

- Accuracy and consistency of data
- Design visualization
- Ease of quantity take off

- Multi-user collaboration
- Energy efficiency and sustainability

2.5.2.1 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 (Kymmell, 2008).

2.5.2.2 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 (Kymmell, 2008).

2.5.2.3 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 equipment 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 (Kymmell, 2008).

2.6 IMPLEMENTATION OF BIM

As successful implementation needs to be framed by a well thought-out strategy, it is of interest to look into the literature to find out which studies have been realized so far and in which way it could assist projects. BIM integration is a complex objective to achieve and involves multiple issues that have to be taken into account differently according to each organization context.

BIM implementation can be seen from several "views", depending on what the project owner's aim is (Hartman, 2008). Technological issues can be the main concern (Ariyici, 2011), as well as the new functionalities allowed by the implementation or its maturity. Hartmann and al. (Hartman, 2008) also note that the industry suffers from a poor amount of practical experiments led on theoretical basis and insist above all on the need to adapt BIM to the company's requirements, and not the opposite, in order to trigger the least resistance to change possible, and to disrupt the existing workflows as little as possible (Gu, 2010). It also implies that studies often focus only on very aggregate levels and that firms lose from the lack of concrete advice. The point is reinforced by Ariyici, (2011) and their approach toward onsite implementation.

In addition to the definition of the expectations about BIM use, it is also relevant to assess its maturity in the organization with levels depicted in object-based modelling, model-based collaboration and network-based integration. This evaluation can be used to enlighten firms about their current situation so they can prioritize the jobs to be done.

It is indeed a central aspect in order to evolve towards a wider integration of BIM in the industry, as demonstrated by (Eastman, 2011) with a description of the Capability Maturity Model (CMM). This tool has been developed by the National Building Information Modelling Standard (NBIMS) and provides a maturity index through an organized assessment of BIM use and happening business processes in a company. The final mark obtained with the CMM is built from several criteria about the main issues of BIM.

2.6.1 Challenges to BIM in Construction Industry

The implementation of BIM is depending on the people, technology and the environment (Gu, 2010). People and process are the key for improvement and changes, while the working environment and IT infrastructure are enablers without which the first two elements cannot be sustained (Gu, 2010).

Previously in the market, there are too many research devoted to BIM is focused on developing technological solutions and technique that is aimed to be the standard and guideline to adopt the design, construction and operational phases of the building. However, recently a successful and completed research had been done indicates that there is range or scale in determining the success of BIM adoption in construction industry. It is found that these behaviours collectively resulted in the formation of the differentiated project team culture, sub-optimal the usage of IT and minimal utilization of BIM capabilities (Grilo & Jardim-Goncalves, 2010).

Hence, the intention to adopt the BIM technology always have to come first before the adoption process begins (NAP, 2009). For instance, the top management's has the intention to adopt with the BIM technology which it will become the indicator of their subsequent decisions (behaviour). Therefore, it can be conclude that the top management or executive is the one who is responsible for the intention to adopt the innovation from the initial stage with the belief that this innovation have huge potential gains and benefit to them (Grilo & Jardim-Goncalves, 2010).

Moreover, NAP (2009) also stated that the organization with appropriate existing technology may adapt the new innovation in IT easily compared to those who are don't. Additionally, they also revealed that the organization 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, characteristics of the industry and project, individual's resistance to change, it is also related to the risks involved in the transformation, the uncertain outcome of the new technology and et cetera.

2.6.1.1 Interoperability

Interoperability is the ability to manage and communicate electric data among owners, clients, contractors, and suppliers and across a project's design, engineering, operations, project management, constructions, 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 required 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 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 realise 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 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 Modelling (BIM) (Grilo & Jardim-Goncalves, 2010).

2.6.1.2 Stakeholders

Major stakeholders play and important role for the implementation of 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, partnership and collaborations. The involvement of private sectors would influence string commercial incentives for developing new software or increasing 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 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 public and private sector is at the initial stage or non-existent (Grilo & Jardim-Goncalves, 2010).

2.6.1.3 Modelling Guidelines

As refer to USA or UK which are success in changing the construction practice, their government are setting out a BIM guideline in helping the industry in facing 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 in success in the acceptance of nationwide. Therefore, it should be notes that modelling guidelines is essential in accelerate adoption of BIM and the successfulness of implementation is depends on the cooperation between the public and private sectors.

2.6.1.4 Client's Demand

In the local industry, many stakeholder are scare of changes of the scare of the uncertain outcomes of the change 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 increase the 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 a new innovations to help maintain of enhance its competitive edge.

2.6.1.5 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.

2.6.1.6 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 while 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 the information models, the confusion about the precise legal effect of adopting BIM may arise. The identified legal issues are as below: (Udam, 2012).

- Contractual framework for incorporating BIM
- Model management and other roles
- Intellectual property rights and data management
- Reliance on data
- Liabilities
- 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 incorporated by reference into the various contracts in use in the industry to minimize risks and ensure successful BIM powered projects (Udom, 2012).

2.6.1.7 Issues of Training and Learning

Implementation of new technology as BIM technologies are costly in term of training and changing works flows and work processes. The investment in software and hardware are typically exceeded by the training cost and initial productivity loses. Often most services providers are not willing to make such and investment unless the perceived the long term benefit to their own organization and or/if the owner subsidizes the training costs (Hartmann, 2008).

2.6.1.8 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 expand to all areas of the company.

2.7 USE OF BIM IN CONSTRUCTION MANAGEMENT

There are many uses of BIM for each project participant. Figure 2.1 depicts these uses for the planning, design, construction and operation phases:

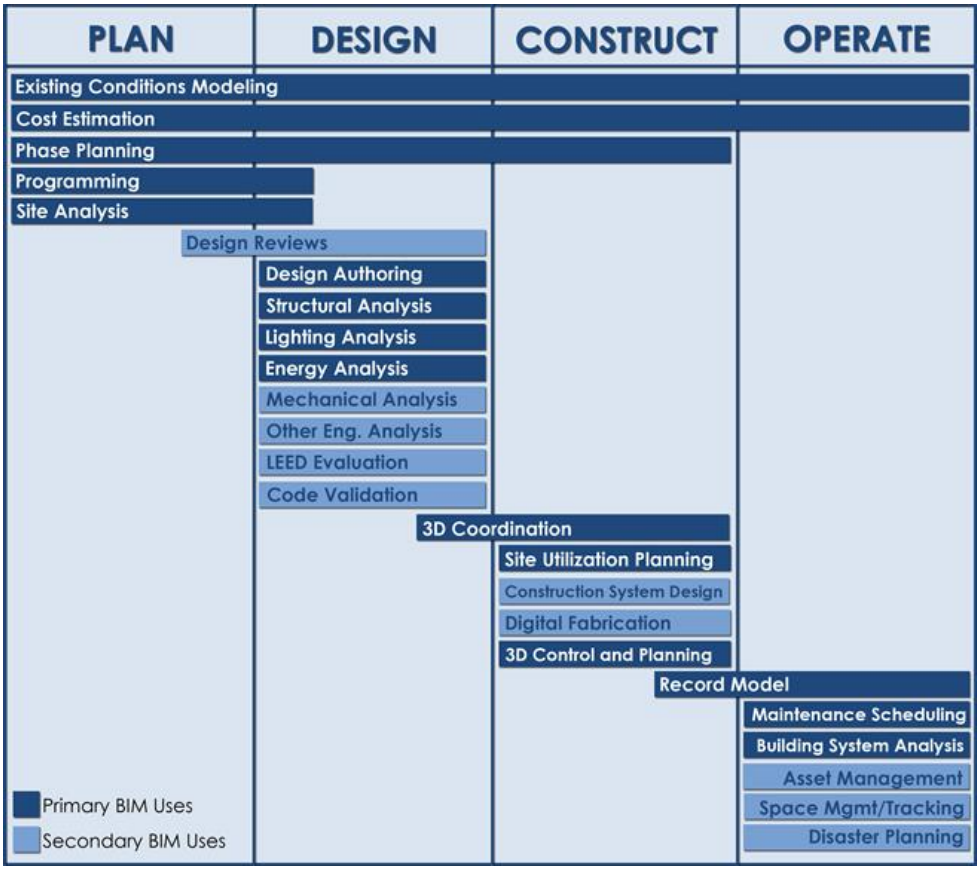

Figure 2.1 Uses of BIM throughout a Building Cycle

Source: Hartmann (2008)

During the design phase, the use of BIM can maximize its impact on a project since the ability to influence cost is the highest. The team can be creatively come up with ideas and provide solutions to issues before problems become high cost impacts to the project. This can be realized through the cooperation and coordination of the entire project staff. Therefore, it is extremely important to have a good collaborations. The use of BIM especially enhances the collaborative efforts of the team. The architect and engineer can test their design ideas including energy analysis. The construction manager can provide constructability, sequencing, value and engineering reports. They can also start 3D coordination between subcontractors and vendors during early stages of design. The owner can visually notice if the design is what he is looking for. Overall, the BIM promotes the collaboration of all of the project participants.

There are beneficial uses of BIM during the construction phase. However, the ability to impact the cost in a project reduces as the construction progresses. Several uses include sequencing, cost estimation, fabrication and on site BIM. These uses are later discussed in detail.

During the post construction phase, maintenance scheduling, building system analysis, asset management and space management and tracking, disaster planning, and record modelling can help to maintain the building throughout its lifecycle. Ideally, the building automation system (BAS) which controls and monitors the uses of mechanical and electrical equipment can be linked to the record model to provide a successful location based maintenance program. Furthermore, building system analysis including energy, lighting and mechanical can be used to measure building’s performance. Moreover, upgrades may be initiated to various equipment and components of the building.

2.7.1 Visualization

Building Information Modelling (BIM) is a great visualization tools. It provides a three dimensional virtual representation of the building. During the bidding phase of the project, the construction manager can provide renderings, walkthroughs, and sequencing of the model for a better communicate the BIM concept in 3D.

Visualization provides a better understanding of what the final products may look like. It takes away thought process of bringing the different traditional 2D views together to come up with 3D view of a detail. Furthermore, virtual mock-ups such as laboratories or building envelope can be provided to the designer and the owner. This would help to visualize, better understand, and make decisions on the aesthetics and the functionality of the space. The virtual mock ups helps to communicate and collaborate among the project participants. It promotes planning, and sequencing the curtain wall construction. Even though a virtual mock up is cost efficient in comparison to the physical mock up, a physical mock-up may be still required if a member such as casework drawer or an assembly of the building such as curtain wall need to go through a series of physical tests. Hence, virtual mock-ups could become a good standard to initiate the mock up process and an actual mock-up may be necessary after the virtual mock up is approved.

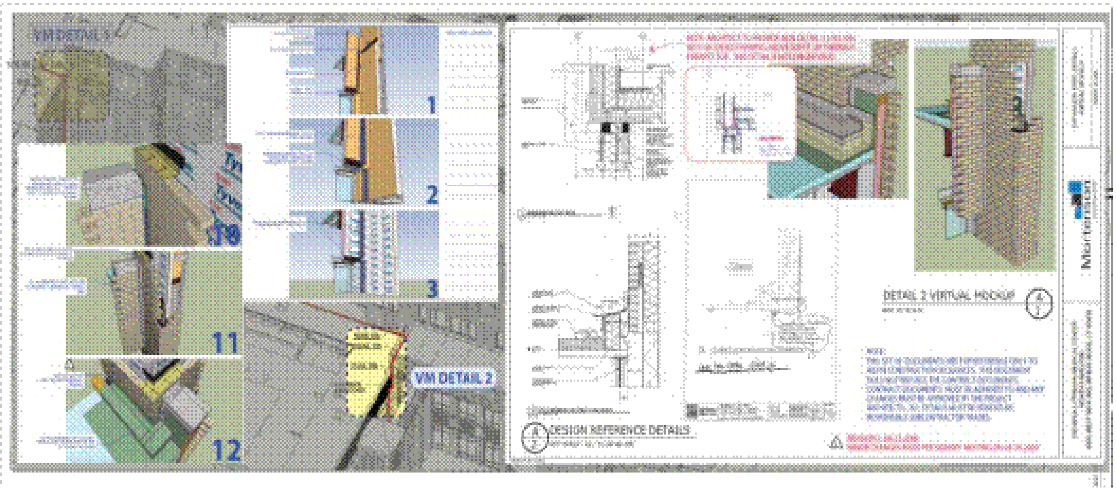

Figure 2.2 Uses of Virtual Mock-ups in the Detailed 3D Shop Drawings

Source: Khemlani, 2011

2.7.2 3D Coordination

Collaboration of the construction team with the architect, engineer and the owner is preferred to be started on early stages of design phase. At the time, the Building

Information Modelling shall immediately be implemented. If the architect is only providing 2D drawings, then the construction manager should convert the 2D drawings to 3D intelligent models. When the speciality contractors, especially the MEP contractors and the steel fabricators are involved, they need to spatially coordinate their works. The 3D coordination can be started right after the model is created to ensure that any same space interference (hard clash) or clearance clash (soft clash) conflicts are resolved.

Overall, the coordination efforts of construction manager and speciality contractors in advance of construction help to reduce design errors tremendously and to better understand ahead of time the work to be done. For example, Research 2 Tower Project for Colorado Denver Health Science Centre distinguished itself with the implementation of BIM in comparison to Research 1 Tower Project which had major complex mechanical system problems. The BIM usage for Research 2 Tower Project included 3D MEP coordination as shown in figure 2.3, work planning for concrete placement, and assembly instruction models. The benefits for Research 2 Tower Project included 37% reduction in coordination RFIs, and 32% reduction in coordination change orders (Young, 2009).

Figure 2.3 Complex MEP System at Research 2 Tower Project, Colorado Denver Health Science Centre

Source: Young, 2009

2.7.3 Prefabrication

Prefabrication reduces field labour cost and time and increases accuracy in a good quality construction. There are more tools and options readily available in a controlled environment in the jobsite to perform work more precisely, and less costly in a shorter period of time. Prefabrication requires design and field accuracy. Building information models can provide this level accuracy by including the specifications, sequence, finishes, and the 3D visual for each component. However, the construction team mist make sure that the BIM is interoperable with the software used by the fabricators. This way the contractors can use the BIM and generate details for the product in their fabrication software. Once the details are approved, the products can be fabricated using Computer Numerical Control (CNC) machines. Furthermore, the construction managers must administer the procurement schedule of the product. Overall, the fabricated products must be delivered to the jobsite on time.

Difficult steel connections generated in Building Information Modelling can be welded offsite. The welding of these small complex elements in advance of steel erection can save time and money. Furthermore, BIM helps to timely modify designs to eliminate or reduce use of beam penetrations that may result from MEP conflicts. A few beam penetrations may become inevitable for complex project. A good coordination of these penetration with BIM technology advocates determining the beam penetration locations and prefabricate offsite. Prefabricated beam penetrations would save tremendous time, money and effort in comparison onsite beam penetrations. Moreover, roof penetrations for concrete rooftops should be sleeved prior to concrete pour at the roof level. Supplemental steel for each penetration may be required. These penetrations can be coordinated with BIM when the speciality contractors are on board (Kacprzyk, 2014).

Curtain wall systems whether panelised or stick system, can be used with BIM to prefabricate parts and components. Panelised curtain wall system may be considered for the schedule purposes. Stick systems require the use of assembly of each one of the components onsite whereas the panelised system already come prefabricated with all the components which include insulation, glazing, stone, framing, etc.

Walls, rooms, and houses can be virtually designed and constructed with Building Information Model. These walls, rooms and houses can be prefabricated with roughed mechanical electrical, plumbing (MEP) components. Final MEP connections can be made once the prefabricated components are assembled onsite.

In healthcare and biotechnology projects, various equipment such as Biosafety Cabinets (BSCs), fume hoods, autoclaves, cage washes, MRIs, etc. may be required. This equipment may be required. This equipment may require some type of coordination with MEP contractors. For instance, fume hoods may come with prefabricated piping for vacuum, gas or nitrogen lines at laboratories. BIM can be used to determine the exact location of the fume hood and more importantly, the drop in location to the prefabricated piping at the fume hood. The enables the in-wall roughing and plumbing drops of the piping work before the fume hoods come to the site. Moreover, the electrician can pull cables to junction box to later tie into the circuits for lights outlets and fan. Lastly, the ductwork contractor can use the information from the BIM to drop its branch duct so the fume hood can later be tied in. overall, Building Information Modelling can help achieve the implementation of the MEP roughing work by promoting collaboration of information exchange between the subcontractors.

BIM can help to coordinate between casework installers and MEP contractors. For example, island benches (cores) are prefabricated with electric outlets and gas turrets. BIM can be used to determine the roughing locations. Then the electrical circuits of the island benches can be roughed to a junction box. The plumbing pipes can be fed to the horizontal branches above the ceiling. Overall, the roughing can be completed successfully with use of Building Information Modelling process.

Pipe manufacturer could use BIM to gather coordinated piping locations, lengths and sizes for its fabrication software as long as the interoperability is possible. This allows in-wall drops including hot, cold, drain/vent, vacuum, etc. to be prefabricated. The drops typically stick out a foot from the wall to provide connection to the horizontal branches above the ceiling. Furthermore, if pipes need to be weld, they must come at manageable sections. Pipes typically come to jobsite 5 to 10 feet sections. Welding small sections of black iron pipe with four inches or bigger diameter would be feasible to weld offsite whereas two 10 foot sections welded offsite would not be manageable. Also offsets and joints would prefer to be prefabricated. Overall, it is ideal to prefabricate all the small pieces in a controlled environment with readily available equipment which would yield more efficient, higher quality, and less costly products (Kacprzyk, 2014).

BIM can be used to enhance the information exchange of the products between participations. Furthermore, it is used to virtually coordinate the location and routing of the products. Based on this information, the products can be detailed using the fabrication software. Once the material is prefabricated and arrives on site, the foreman of the speciality trade coordinates with the general superintendent to ensure that he is making the virtual design and construction reality.

2.7.4 Construction Planning and Monitoring

The construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and space. The schedule of the anticipated construction progress can be integrated to a virtual construction. The utilization of scheduling introduces time as the 4th dimension (4D).

There are two common scheduling methods that can be used to create 4D Building Information Model. These are critical path method (CPM) and line of balance. In the Critical Path Method, each activity is listed linked to another activity, and assigned durations. Interdependency of an activity is added as either predecessors or successors to another activity. Moreover, the duration of the activities are entered. Based on the dependency and duration of the activities, the longest path is defined as the most critical path. The activities defined the longest path are defined as the critical activities. These activities do not have any float. In other words, if these activities are not completed within anticipated duration, the total duration of the project will be further pushed out. Overall CPM is a commonly used technique that helps projects stay within schedule.

Line of Balance technique uses location as the basis for scheduling. This method is an alternate to the CPM. It is advantageous for repetitive tasks to increase labour productivity. In this method, the activity durations are based on the available crew size and the sequence of the location. Productivity of the labour force can be altered as needed to accurately depict the construction schedule. The approach focuses on the locations being completed by a trade before the other trade moves in. this reduces the number of mobilizations and resources. Overall, Line of Balance is a good scheduling method to plan and monitor repetitive tasks during construction progress (Yan, 2008).

The planning through using BIM enhances site utilization, space coordination, and product information. A 4D model can either include a site logistics plan or tools such as SMARTBOARD on top of a virtual construction can be utilized to visually depict the space utilization of the job site. The model must include temporary components such as cranes, trucks, fencing and etc. traffic access routes for trucks, cranes, lifts, excavators, etc. need to be incorporated into the BIM as part of the logistics plan. For example, the site logistics planning for the Hennessy Centre steel erection is depict in figure 2.4 (Yan, 2008). Moreover, the site utilization consists of lay down areas, site work progress, and location of trailers and equipment and hoist assembly.

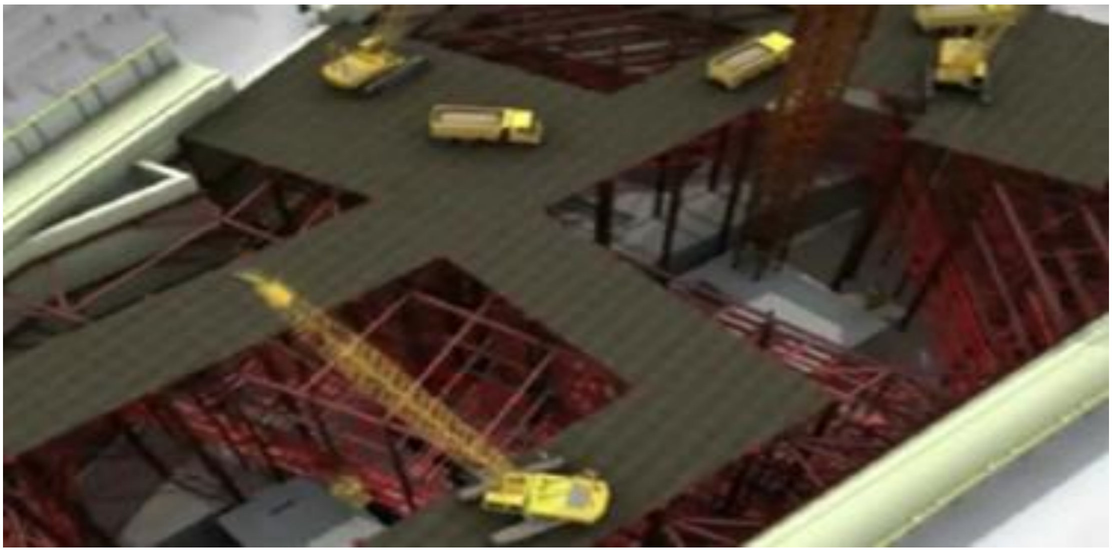

Figure 2.4 Hennessy Centre Safety and Site Logistics Planning

Source: Collins, 2011

4D BIM can be used as a visualization tool to identify the safety features that will be required at different times. Based on those observation, the temporary safety related structures such as rails and fences can be modelled in the BIM and the safety related activities can be integrated into the schedule. Once the model is used as a planning tool for safety, the 4D model can be used to monitor the safety precautions taken at the jobsite. Overall, 4D BIM can be used as a proactive approach to enhance the planning and monitoring of the jobsite safety.

Construction managers must plan for coordination, shop drawings approval, fabrication, transportations and installation times. They need to make sure the leads time for the material is accounted for so that it can have enough time to be installed or assembled. They can update this information on their 4D models.

There are several field data acquisition systems that can be used with 4D BIM to keep track of the progress of the construction. Radio Frequency Identification and 3D laser scanning Radio Frequency Identification (RFID) can be used to keep track of the material delivery status. The used of RFID is ideal for the prefabricated components of a project such as precast concrete panels. RFIDs can be linked into the BIM to show that the elements are in the correct location. For instance, a tagged projector can be linked to element’s type property in the BIM. The BIM and RFID integration helps to keep track of the location of the projector and indicate that the material is in the designed location once it is installed (Meadati, 2010).

RFIDs can be relatively be used to plan and monitor the workforce. They can be tagged to the hard hats of the trades to identify the manpower and the location of the workers of the day (Kacprzyk, 2014). The daily activities of workman can be monitored closely to ensure that the manpower is adequate and that the labour activity is suffice to the planned 4D schedule. 3D Laser Scanning can be used to monitor the progress of the designed Building Information Model. 3D laser can scans and register points clouds of geospatial information which then can be processed to the designed Building Information Model. At that stage, the scanned as built-data can be manually checked against the original designed model to detect and deviation. However, there are no current algorithms to make this an automatic process (NAP, 2009). Overall, the 3D laser scanning technology can be a good quality control tool for a new project. For renovation projects with no 3D models, the laser scanning can be a good process to identify the current location and status of building components. The visualization can be helpful for space coordination in the renovation projects.

Construction managers can use BIM and robotics total station technologies for accurate building practices. Site survey points generated in the Building Information Model can be uploaded to the robotic total station. Based on the points generated from the model, the field staff then can lay out all of the points. For instance, the accurate positioning of the hangers would ease the coordination of the MEP contractors. Furthermore, field staff can survey the components of the building with robotic total station to ensure that they are built per designed model within acceptable tolerance range. This proactive quality control approach would prevent any subsequent conflicts. Overall, robotics total station uses the information from BIM to survey both construction and quality control purposes.

Planning and monitoring is an extremely important part of the construction. The construction manager can use various 4D BIM enabled tools to enhance the quality control process. Overall, construction planning and monitoring with 4D BIM is a great process to build a facility per the designed model.

2.8 CHALLENGES OF BIM IMPLEMETATIONS

Many issues limiting the adoption of BIM in the AEC-industry is connected with the BIM tools and their development. Besides numerous benefits for project stakeholders there are many risks and barriers to implement BIM. Currently the users demand on BIM are not always met by technical possibilities with BIM as it is currently supplied. The reason for the slow BIM implementation is not simply one single issue, but rather the combination of several issues (Kiviniemi, 2013). In order for the BIM to adopt on a border front in the AEC-industry all of these issues must be considered.

2.8.1 People

In order for BIM to be successful in its implementation all industry actors have to be informed about the potential benefits to their professions (Gu, 2008). Together with that, all people involved with BIM needs to be skilled in its use in order to utilise these benefits (Arayici, 2009). Therefore, one of the barriers limiting the BIM adoption is connected with the individual actually working with the new technology and their needs of new roles and training to support the change.

2.8.1.1 Roles and Responsibilities

Adoption of BIM will affect the roles and relationships of the participating actors as well as their work processes (Gu and London, 2010). One new role in construction project is presented by Rizal et al (2011) in the form of a model manager.

Connected to the change technology there is need for a coordinating role in the form of a BIM model manager (Gu and London, 2010). The role of model manager will deal with the system as well as the other project participants. She will provide and maintain technological solutions required for BIM functionalities, manage information flow and improve the ICT skills of the other stakeholders. This expert role will demand knowledge in both ICT and construction process. This actor will not take part in the decision making regarding design or engineering solutions, or the organizational processes, but rather focus on the successful and collaborative use of BIM by all stakeholders (Yan, 2008).

2.8.1.2 Training and Education

When adopting BIM it is vital that the individuals are sufficiently trained in the use of the new technology in order for them to be able to contribute to the changing work environment (Gu and London, 2010). The importance of training was also one of the issues most often discussed. The implementation of BIM to be successful for all affected members must be skilled in the use of BIM in regards of their specific field (Arayici et al. 2009).

Simultaneously, a study by Yan and Damian (2008) revealed that most companies in their study who did not use BIM believed that the training would be too costly in regard to time and human resources. Further they argue that the issue of training is the largest barrier to BIM adoption because of the costs following to the change. Decisions are mainly taken on the ground of business perspective, making a profit. Because of the insufficient number of case studies showing the potential financial benefit of BIM the AEC-industry is generally not interested in investing. There is also social and habitual resistance to change as many architects are familiar and satisfied with their current design tools and works processes and are sceptical to the benefits if this new technology. This results in that some actors are not interested in learning on how to use BIM associated tools (Yan and Damian, 2008).

2.8.2 Technology

Many issues limiting the adoption of BIM in the AEC-industry is connected with the BIM tools are development. These issues are mostly aspects of poor interoperability between different BIM programs and tools, but this is not the only areas of concern. Currently the user's demands on BIM are not always met by technical possibilities with BIM as it is currently applied.

2.8.2.1 Hardware

According to Haron (2013), to run BIM software smoothly, the workstation require and high capacity of RAM and graphic card and a more powerful processor. An adequate workstation is a must to avoid disruption to the BIM implementation and therefore identified as another readiness criterion. Any company therefore must carefully plan their hardware either to go for upgrading their hardware or totally change for a new workstation. The justification must not look for a short term plan but should plan for at least 3 years duration to include BIM advancement.

2.8.2.2 Technical Support

The company has engaged product demonstration and training prior to software acquisition to evaluate the capability of the software vendor in providing services, which includes a review on a vendor's track record and the availability of technically competent personnel. The capability of the software vendor was identified important by both interviewees to assist the BIM implementation and justify the company approach for evaluating their capability. Therefore, having tools or technique to evaluate the capability of the software vendor is identified as readiness criteria. Meanwhile, the adequate technical support is a must to implement BIM. This lies on the ground of supporting the staff and avoiding disruption of the implementation. Although it is compulsory for the software vendor to provide technical support such as troubleshooting the technical problem, the early stage of BIM environment in Malaysia requires the company not to rely on and expect too much from the software vendor to assist implementation. Normally, software-associated technical problems can be solved by the software vendor but other problems required third party expertise such as BIM consultants or business partners to get involved to resolve the problem. Therefore, adequate technical support features as another readiness criterion (Haron, 2013).

2.9 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 promote BIM adoption.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology is a system of broad principles or rules from which specific methods or procedures may be derived to interpret or solve different problems within the scope of a particular discipline and a set of practices. Collection of data is one of the most important part to achieve a successful research. The objectives of this research will be achieved through several steps which are conducting interviews, questionnaire surveys and also through literature review. The data that had been collected will be analysed, followed by discussion, recommendation, suggestion and lastly comes to conclusion.

3.2 INSTRUMENT FOR DATA COLLECTION

To achieve the aim and objectives of this research, questionnaire survey will be send out to the targeted person to answer the questions. This method is being used because apart from being inexpensive and flexible, questionnaires are also a practical way to gather data as we can send it to our targeted group of respondent and manage it according to our way. Next, by doing questionnaire, it is quick and easy to collect results with online and mobile tools within short period.

However, there are still some problems that may occurs when questionnaire survey is being conducted. Firstly, dishonesty can be an issue. Respondents may not be 100 percent truthful with their answers as this can happen for a variety of reasons, including social desirability bias and attempting to protect privacy. Next, the issue with not presenting questions to users face-to-face is that each may have different interpretations of the questions. Without someone to explain the questionnaire fully and ensure each individual has the same understanding, results can be subjective. This miscommunication can lead to inaccurate results.

3.2.1 Questionnaire Survey Design

The questionnaire survey had been designed to collect the quantitative data for this research and will be distributed to the local construction organisation. This questionnaire consists of three sections, which are Section A, Section B and Section C. Section A is basically about the particular of the respondent which are including their profile, organisation name, nature of the company, the size of the company and the job position of the respondent. For Section B, identify the benefits of BIM implementation in construction industry which consists of 16 benefits and the respondent will scale it from 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree). For Section C, identify the challenges and barriers of BIM implementation in construction industry which consists of 25 challenges through literature review and the respondent will scale it from 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree). The challenges and barriers of BIM implementation in construction industry will be categorised into 3 elements which are people, technology and process. After the questionnaire had been collected, all the data will be gathered, computed, and analyse.

3.2.2 Interview

In order to optimize the data collection method, both quantitative and qualitative data collection method is being employed. The quantitative data will be collected through the questionnaire survey, while the qualitative data will be collected through simple interview. Both method is being implemented due to minimize the limitation of both approaches. The interview will be conducted through personal interview or phone. They will be given certain time to be chosen according to their free time to answer the question during the interview session.

3.3 RESPONDENT OF THE STUDIES

For the respondent of this research, 50 construction, consultant and architecture companies in Klang Valley will be randomly selected. The respondent may be the employees from the company which are the Project Manager, Engineer, Quantity Surveyor and other higher management of the company. All the respondent will be selected by random sampling as this method is the most efficient sampling method. This type of sampling method also being conducted because each member of the population has the equal chances and opportunity to be the respondent in this research. Hence, valid data will be achieved.

3.4 DATA ANALYSIS

The data received from the two methods which are the survey questionnaires and interviews will be collected, computed and analyse. All this data will be received from the chosen technical professional who are involved directly in construction industry. This data will be analysed by using average index method. Bar charts and graphs will be represented to show the highest cause that contribute to challenges and barriers in building information modelling implementation in construction industry.

Next, frequency analysis also will be conducted to show the percentage of the respondents with relation to the variables in the questionnaires. The area of interest are nature of the company, size of the company, job position, salary range and group age. All this data will be analysed and interpret in pie chart to give a clearer view of the frequency.

In order to analyse the data that had been collected, the average index method will be used to gather the level of importance of the data taken as shown in Table 3.1

Average Index =

$$\frac{\sum(1X_1 + 2X_2 + 3X_3 + 4X_4 + 5X_5)}{N}$$

X_1= Number of respondent who is Strongly Disagree

X_2= Number of respondent who is Disagree

X_3= Number of respondent who is Neutral

X_4= Number of respondent who is Agree

X_5= Number of respondent who is Strongly Agree

N = Total number of respondent

Table 3.1 Average Index

Average Index	**Level of Importance**
0.0 ≤ Average Index < 1.50	Strongly Disagree
1.50 ≤ Average Index < 2.50	Disagree
2.50 ≤ Average Index < 3.50	Neutral
3.50 ≤ Average Index < 4.50	Agree
4.50 ≤ Average Index < 5.00	Strongly Agree

3.5 RESEARCH FRAMEWORK

Figure 3.1 below shows the methodology that will be done through this research. This framework is clearly described the steps that will be work out to establish this research study.

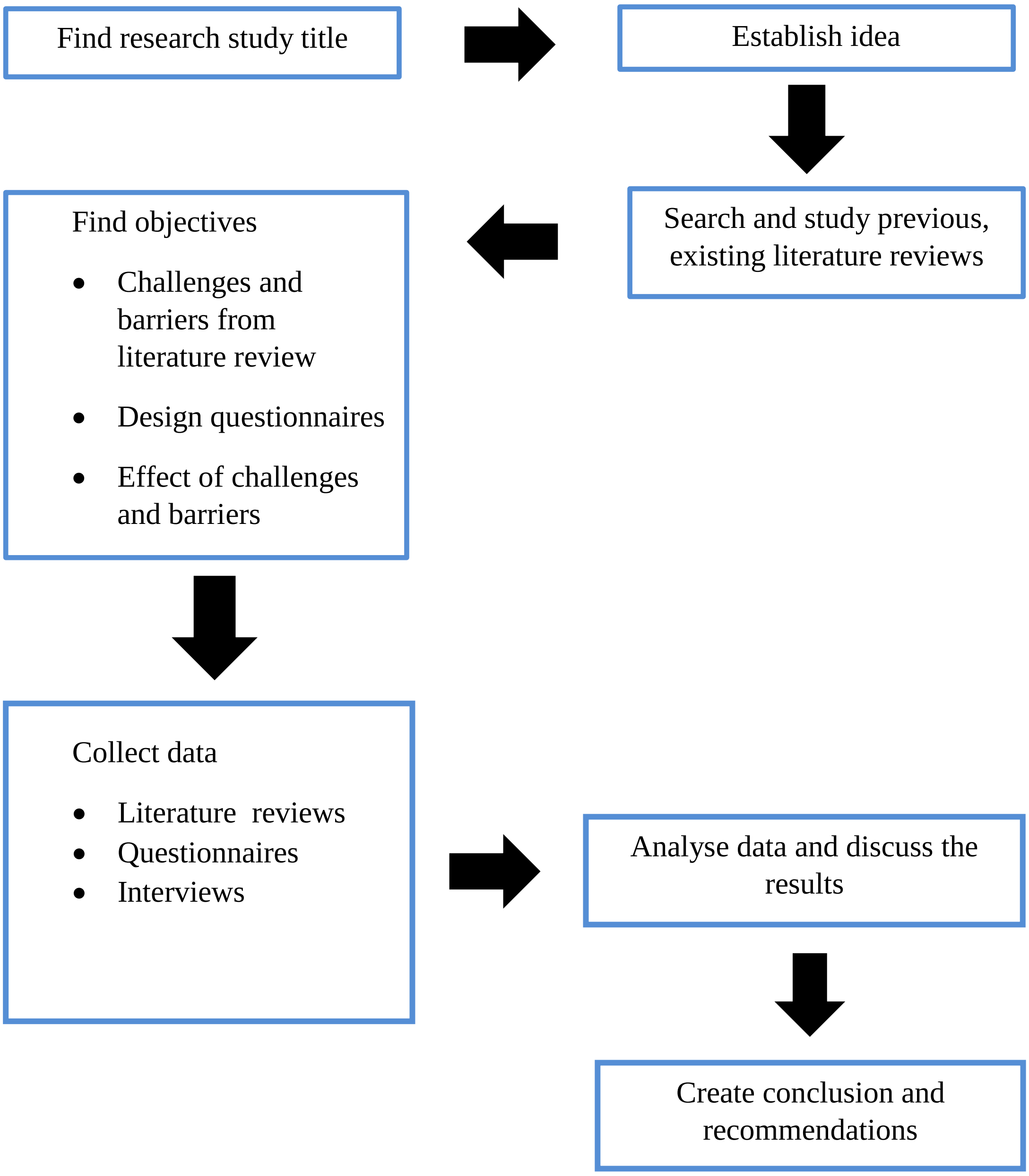

Figure 3.1 Research Methodology Framework

CHAPTER 4

RESULTS & DICUSSION

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 analysis while the discussion on the results has been carried out to provide a clearer picture and understanding of the research.

4.2 QUESTIONNAIRE ANALYSIS

50 sets of questionnaires are being distributed by Google Form to each and every company. The types of company involved are Construction Company, Engineering Consultant, Developer and Architecture Firm. The questionnaires that collected back are 100%.

4.2.1 Respondent's Background

4.2.1.1 Nature of the Firm

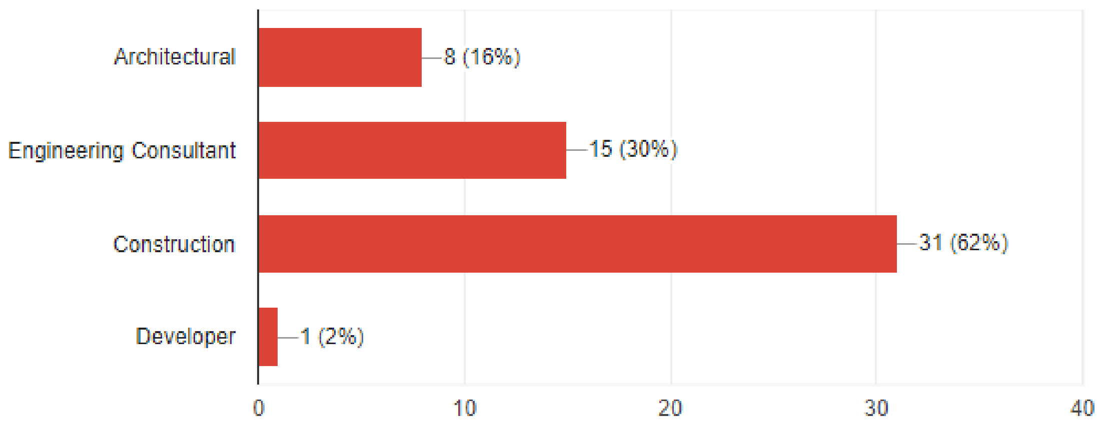

Figure 4.1 Nature of the Firm

According to the questionnaire distributed, we only focus our survey on Engineering Consultant, Construction Company, Architecture Firm and Developer only. This is because this research is being done mainly on project implementation. Therefore, during the distribution of the questionnaire, only Engineering Consultant, Construction Firm, Developer and Architecture Firm are targeted. According to the graph shown above, the most data is collected from Construction Company which is 62% which means 31 of the respondents, 30% which means 15 respondents from Engineering Consultant, 16% is from Architecture Firm which means 8 respondents and the least is from Developer which contribute only 2% which is only 1 respondent. The total respondents are 50.

4.2.1.2 Job Positions

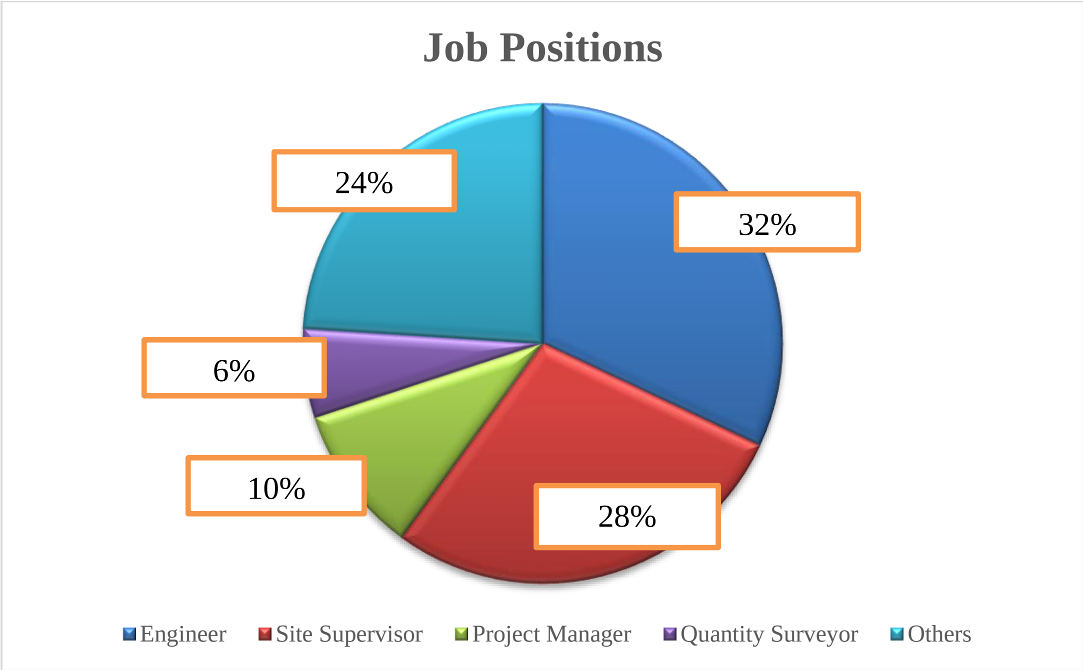

Figure 4.2 Job Positions

As shown in the pie chart above, Engineer contributes the most of the job positions, which is 32% which means 16 out of 50 respondents. This is because Engineer mostly can be found in both of the Construction Company and Engineering Consultant. 28% which is 14 respondents are holding the title of Site Supervisor. 5 respondents which made up of 10% of the job positions is the Project Manager while 6% which is 3 respondents are the Quantity Surveyor. 24% is made up of others which include Project Coordinator, Architect, Assistant Project Manager, Architectural Assistant, Technical Assistant, Technician, Trainee, Purchaser, Drafter and also Clerk.

4.2.1.3 Amount of workers in company

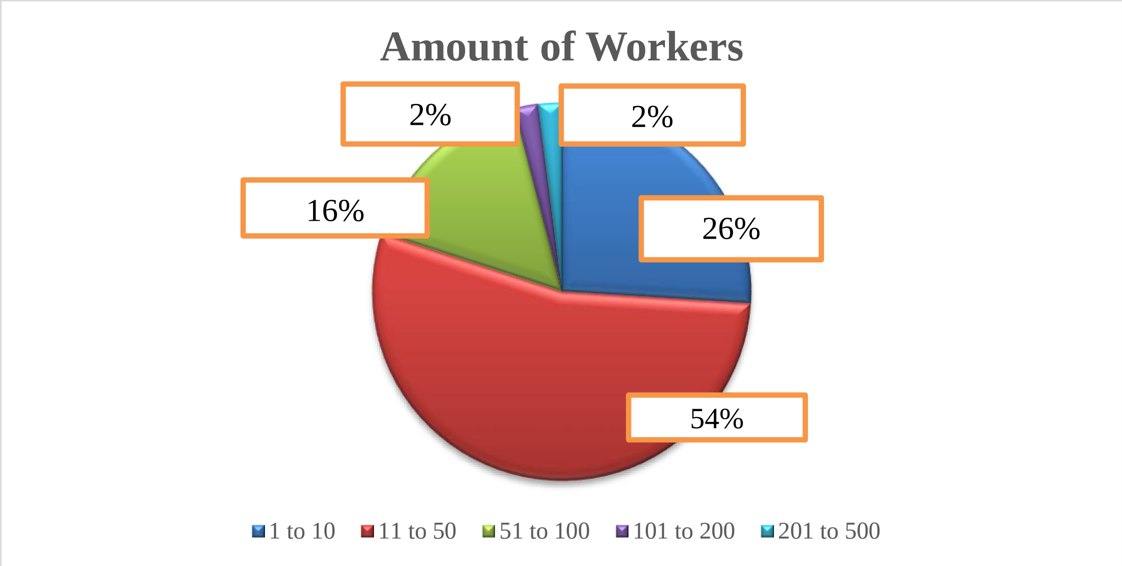

Figure 4.3 Amount of workers in company

As shown in the pie chart above, most of the respondent companies are small-mediums companies. The biggest proportion is contributed by the range 11-50 workers in the company, which is 54% which also mean 27 out of the total of 50 respondents. This is followed by 1-10 workers in the company. This range contributed a total of 26% which also means 13 out of 50 respondents. Range of 51-100, 101-200 and 200-500 also contribute 16%, 2% and 2% respectively. There is no company that have more than 500 workers in this survey.

4.2.2 Causes of Challenges and Barriers of BIM Implementation

Table 4.1 Remarks for the Benefits of BIM Implementation

Benefits of BIM Implementation	Remarks
Reduces rework	B1
Improves productivity	B2
Reduces conflicts and changes during construction	B3
Clash detection	B4
Reduced errors	B5
Improve coordination and collaboration	B6
Reduce risk mitigation	B7
Improve predictability of outcomes	B8
High level of customization and flexibility	B9
Optimization of schedule and cost	B10
Easy maintenance of building life cycle	B11
Faster drafting without loss of cost and quality	B12
Faster delivery of project	B13
Easy prefabrication of larger and complex parts	B14
Improve review and approval cycles	B15
Improve overall project quality	B16

Table 4.2 Remarks for the Challenges and Barriers of BIM Implementation

Challenges and Barriers of BIM Implementation by People	Remarks
Professionals resistant to change	P1
High cost of training to develop people's competency	P2
Lack of knowledge on BIM implementation	P3
Lack of ready pool of skilled manpower	P4
Inadequate education	P5
Lack of technical skills	P6
Reluctant of other stakeholder (eg: engineer, architect, contractor)	P7
Lack of knowledgeable/experienced partners	P8
Lack of proof of the benefits of BIM	P9
Lack of BIM demand	P10

Challenges and Barriers of BIM Implementation by Technology	Remarks
High cost to install BIM tools and software	T1
High cost to install hardware and facilities	T2
Complexity of the BIM software	T3
Current method is satisfied to deliver current project	T4
Problem of interoperability	T5
Lack of BIM standards for model integration and management	T6
Liability and intellectual properties	T7
Onsite personnel do not have adequate support to use BIM	T8
Current professional indemnity insurance terms	T9

Challenges and Barriers of BIM Implementation by Process	Remarks
Fragmented nature	PR1
Changing of roles and responsibilities	PR2
Complexity of the BIM software	PR3
Immediate benefits do not accrue to the key adopter	PR4
Lack of determination of ownership	PR5
Absence of standard BIM process flow	PR6
Lack of collaborative work processes and modelling standards	PR7
Lack of legal/contractual agreements	PR8
Current professional indemnity insurance terms	PR9
Lack of government's lead/direction	PR10
Confusion surrounding what BIM truly is and how to adopt it	PR11
BIM implementation initially affect the productivity	PR12
Transition from CAD-based to BIM based	PR13

We analyse the data collected by using average index method. The average index (A.I) value was calculated by using the following formula:

Average Index =

$$\frac{\sum(1X_1 + 2X_2 + 3X_3 + 4X_4 + 5X_5)}{N}$$

Table 4.3: Average Index for Benefits of BIM Implementation

Benefits of BIM Implementation	**Rating of frequency**												**AI**	**Ranking**
	1		**2**		**3**		**4**		**5**		**Total**			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
B11	2	4	0	0	6	12	19	38	23	46	50	100	4.22	**1**
B9	1	2	1	2	7	14	20	40	21	42	50	100	4.18	**2**
B15	1	2	1	2	8	16	16	32	24	48	50	100	4.16	**3**
B3	1	2	0	0	12	24	14	28	23	46	50	100	4.16	**4**
B7	1	2	1	2	10	20	17	34	21	42	50	100	4.12	**5**
B13	1	2	1	2	11	22	16	32	21	42	50	100	4.10	**6**
B16	1	2	1	2	6	12	28	56	14	28	50	100	4.06	**7**
B10	1	2	0	0	6	12	32	64	11	22	50	100	4.04	**8**
B5	2	4	1	2	9	18	19	38	19	38	50	100	4.04	**9**
B12	1	2	0	0	7	14	33	66	9	18	50	100	3.98	**10**
B4	1	2	1	2	9	18	28	56	11	22	50	100	3.94	**11**
B2	1	2	0	0	9	18	33	66	7	14	50	100	3.90	**12**
B1	1	2	0	0	7	14	19	38	23	46	50	100	3.88	**13**
B14	2	4	1	2	7	14	32	64	8	16	50	100	3.86	**14**
B8	1	2	1	2	10	20	29	58	9	18	50	100	3.84	**15**
B6	2	4	1	2	10	20	28	56	9	18	50	100	3.82	**16**

Table 4.4 Average Index for Causes of Challenges and Barriers of BIM Implementation

Causes of Challenges and Barriers of BIM Implementation by People	Rating of frequency												AI	Ranking
	1		2		3		4		5		Total			
	N	%	N	%	N	%	N	%	N	%	N	%		
P3	0	0	0	0	13	26	14	28	23	46	50	100	4.20	**1**
P1	1	2	2	4	10	20	12	24	25	50	50	100	4.16	**2**
P9	1	2	0	0	11	22	16	32	22	44	50	100	4.16	**3**
P7	1	2	1	2	14	28	11	22	23	46	50	100	4.08	**4**
P10	0	0	1	2	9	18	27	54	13	26	50	100	4.04	**5**
P8	0	0	1	2	7	14	32	64	10	20	50	100	4.02	**6**
P5	3	6	1	2	11	22	15	30	20	40	50	100	3.96	**7**
P6	0	0	3	6	9	18	26	52	12	24	50	100	3.94	**8**
P4	0	0	3	6	11	22	24	48	12	24	50	100	3.90	**9**
P2	1	2	1	2	9	18	30	60	9	18	50	100	3.90	**10**
Causes of Challenges and Barriers of BIM Implementation by Technology	**Rating of frequency**												**AI**	**Ranking**
	1		**2**		**3**		**4**		**5**		**Total**			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
T1	0	0	2	4	10	20	13	26	25	50	50	100	4.22	**1**
T7	1	2	0	0	14	28	14	28	21	42	50	100	4.08	**2**
T9	1	2	0	0	13	26	19	38	17	34	50	100	4.02	**3**
T5	2	4	0	0	9	18	23	46	16	32	50	100	4.02	**4**
T4	0	0	2	4	7	14	29	58	12	24	50	100	4.02	**5**
T8	1	2	0	0	9	18	30	60	10	20	50	100	3.96	**6**
T3	3	6	2	4	11	22	15	30	19	38	50	100	3.90	**7**
T2	1	2	2	4	9	18	28	56	10	20	50	100	3.88	**8**
T6	1	2	1	2	11	22	32	64	5	10	50	100	3.78	**9**

Causes of Challenges and Barriers of BIM Implementation by Process	**Rating of frequency**												**AI**	**Ranking**
	1		**2**		**3**		**4**		**5**		**Total**			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**		
PR7	1	2	1	2	8	16	16	32	24	48	50	100	4.22	**1**
PR1	1	2	1	2	8	16	16	32	24	48	50	100	4.22	**2**
PR5	1	2	1	2	7	14	19	38	22	44	50	100	4.20	**3**
PR13	1	2	2	4	8	16	18	36	21	42	50	100	4.12	**4**
PR9	1	2	1	2	10	20	17	34	21	42	50	100	4.12	**5**
PR3	1	2	2	4	11	22	14	28	22	44	50	100	4.08	**6**
PR11	2	4	1	2	10	20	17	34	20	40	50	100	4.04	**7**
PR4	1	2	0	0	11	22	29	58	9	18	50	100	3.90	**8**
PR12	1	2	0	0	11	22	29	58	9	18	50	100	3.90	**9**
PR8	1	2	2	4	8	16	30	60	9	18	50	100	3.88	**10**
PR10	2	4	0	0	7	14	34	68	7	14	50	100	3.86	**11**
PR6	2	4	1	2	10	20	28	56	9	18	50	100	3.82	**12**
PR2	2	4	2	4	8	16	30	60	8	16	50	100	3.80	**13**

Table 4.5: Average Index for Respective Causes

Causes of Challenges	**5**	**4**	**3**	**2**	**1**	**A.I.**
T1	25	13	10	2	0	**4.22**
PR7	24	16	8	1	1	**4.22**
PR1	24	16	8	1	1	**4.22**
P3	23	14	13	0	0	**4.20**
PR5	22	19	7	1	1	**4.20**
P1	25	12	10	2	1	**4.16**
P9	22	16	11	0	1	**4.16**
PR13	21	18	8	2	1	**4.12**
PR9	21	17	10	1	1	**4.12**
P7	23	11	14	1	1	**4.08**
PR3	22	14	11	2	1	**4.08**

T7	21	14	14	0	1	**4.08**
PR11	20	17	10	1	2	**4.04**
P10	13	27	9	1	0	**4.04**
T9	17	19	13	0	1	**4.02**
T5	16	23	9	0	2	**4.02**
T4	12	29	7	2	0	**4.02**
P8	10	32	7	1	0	**4.02**
P5	20	15	11	1	3	**3.96**
T8	10	30	9	0	1	**3.96**
P6	12	26	9	3	0	**3.94**
T3	19	15	11	2	3	**3.90**
P4	12	24	11	3	0	**3.90**
P2	9	30	9	1	1	**3.90**
PR4	9	29	11	0	1	**3.90**
PR12	9	29	11	0	1	**3.90**
T2	10	28	9	2	1	**3.88**
PR8	9	30	8	2	1	**3.88**
PR10	7	34	7	0	2	**3.86**
PR6	9	28	10	1	2	**3.82**
PR2	8	30	8	2	2	**3.80**
T6	5	32	11	1	1	**3.78**

4.3 DISCUSSION

4.3.1 Benefits of BIM Implementation

4.3.1.1 Easy maintenance of building life cycle

Based on the Average Index (A.I.) value, factor B11 which is easy maintenance of building life cycle shows the highest A.I. of 4.22. BIM tools have enabled comprehensive information about the building to be captured during the design process, ranging from individual building components and locations to relationships between those objects. BIM incorporates building information ranging from geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components product's material, specification, fire rating, U-value, fittings, finishes, costs and carbon content. These features in turn allow designers and engineers to keep track of relationships between building components and their respective construction-maintenance details (Gu and London 2010).

Whilst the benefits of BIM are implicitly understood by the designer, they could become explicit to other project stakeholders such as owners, contractors, subcontractors, fit-out companies, council, etc. In the event of design changes BIM tools can integrate and systematise changes with the design principles, intent and design ‘layers’ for the facility or project (Young, 2009). Moreover, BIM could be used essential for facility management integration. One example is Onuma which offers Construction Operations Building Information Exchange (COBie) files to enable standardized external facility management data integration (Young, 2009). BIM tools provide interoperability opportunities plus the capability for proper integration, allowing inputs from various professionals to come together in the model.

After the project is accomplished, the construction team will pass from the construction team to the facility management team during the commissioning process. Significant configuration of interiors for use will be updated in the model. Details such as communications cabling will sometimes be included in the model. The model may even include information on who is sitting where, so that the space can be optimized.

In maintaining stage, what was originally the Construction Progress Schedule will become the Maintenance Schedule. All operation and maintenance (O&M) documentation for each and every element will be available in, or referenced from, the model. Building maintenance, both planned and unexpected, will be updated in the model. “Best Practices” for maintaining structures and contracting for maintenance services will be applied by integrating data into the model, and owners of multiple projects will share these best practices from model-to-model. This will include who, what, when, where, how, how much, and how many. Contracts for maintenance should be maintained element-by-element, location-by-location, and player-by-player (contacts) in the model (Gu and London 2010).

In repair and improvement stage, all repairs and improvements should be updated into the model. This will include who, what, when, where, how, how much, and how many. If it is found that some element or elements were constructed in a way that is not consistent with the applicable standards, and the building is not performing as expected, the model will include information from construction about who designed, approved, supervised, executed, inspected and approved the assemblies, so that any disputes should only address the applicable elements, locations, and players (Young, 2009)

In learning stage, over time, since that data is structured, it will become information that smart people can use to make smart, informed decisions. Not only will the decision makers have the structured information for the project at hand, they will also have the data from other, similar projects to aid in decision making across projects. This metadata (a set of data that describes and gives information about other data) can be created to further inform best practices (Young, 2009).

See PFCS' publications on Building Lifecycle Management, which argue the position that collecting and organizing building data such that it becomes actionable information is the only way to make smart decisions about building projects. Therefore, a central database of all building related data (BIM), searchable and able to output by building element, location, person/company, or timeline, is an amazing decision-making resource (Young, 2009).

In decommission stage, the decision to update or demolish is a tough one. But it will be made much easier when we can do multiple, cost-effective, A to Z, what-if analysis.

4.3.1.2 High Level of Customization and Flexibility

Based on the Average Index (A.I.) value, factor B9 which is high level of customization and flexibility shows the A.I. of 4.18. The BIM process offers a level of flexibility previously unknown in building design. Architects are able to customize the design and documentation processes fluidly in response to changing client requirements. As such, architecture around the world has become more complex since the introduction of BIM.

In the design development phase, 3D models shift some of the project team's efforts from producing traditional outputs such as (eg, design documents) to more value-adding work (example, exploring more alternatives). According to Tollefsen et al. (2010), the architects saving a lot of times in the design documentation phase result of object oriented libraries and catalogues, parametric properties, knowledge reuse, and various automation tools. During the development of building projects, changes arising from the design conflicts checking are made constantly to fine tune the design. Traditional methods usually do not facilitate change effectively. The creation of design documents can be difficulty and require a large numbers of low-value drafting tasks including manual checking of work.

According to (Hartmann et al., 2008), it also helps architects to identify and eliminates unnecessary repetitive work, improves the quality of design by reducing errors and inconsistencies in drawing production for large number of housing and apartment buildings involve similar building parts or even entire buildings that have similar designs. Furthermore, improvement in drawing production helps designer to maximize client satisfaction and hence gain repeat business by shifting design hours. 3D modelling reduces the number of late design changes that are caused by design errors, incorrect understanding of the design by the owner, or inadequate assessment of existing site conditions. Every time because of the number of subsequent drawing changes, and the riskier it become and cause trouble for the designer. The design changes may not be coordinated among all of the various engineers, consultants and contractors in project team.

4.3.1.3 Improve Review and Approval Cycles

Based on the Average Index (A.I.) value, factor B15 which is improve review and approval cycles shows the A.I. of 4.16. Design applications relate to the pre-planning and planning phase of a project. This section includes initial data collection (laser surveying, existing conditions modelling and site analysis), spatial programming and design authoring. It encompasses includes design review and coordination (Arayici, 2009).

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 (Haron, 2013).

(Hartmann et al., 2008) notes 3D models help the developers to obtain cost estimates, bill of quantities, specifications and schedules from the architect component in just a few hours. Contractors may send material lists to subcontractors and acquire subcontractors' pricing during the preconstruction and bidding phases. They are less likely to overpay or underpay to subcontractors because they can take off quantities accurately from the 3D model. If the design of the projects has to be modified because of buyer-initiated change orders, developers can use 3D models to accurately estimate the cost effects of change orders and immediately provide information to construction site. Architects may design with manufacturers' product libraries so that more off-site prefabrication and assembly are possible in the design phase (Hartmann et al., 2008). By giving exact dimensions for manufacturing, 3D models also create bills of materials (BOM) that are important in acquire the materials needed in construction. It helps shortened the time by streamline the flow of information between engineering, fabrication, erection, reducing batch sizes of shop drawings and making more frequent but smaller orders (Young, 2009).

Hartmann et al (2008) states that modelling and coordinating the MEP systems in 3D provides a better opportunity to prefabricate materials resulting in time and cost savings and fewer errors. Normally only the medium pressure duct is pre-fabricated, the low pressure smaller duct runs are field assembled and the piping is cut in the field. But implementation 3D modelling in Camino Project, all of the plumbing systems and low pressure duct system was pre-fabricated. Increased pre-fabrication on the project and 20 increased productivity that has resulted from a highly accurate bill of materials will resulted in a much better cost control for the subcontractor to performing the work on the project.

4.3.1.4 Reduces Conflicts and Changes during Construction

Based on the Average Index (A.I.) value, factor B3 which is reduces conflicts and changes during construction shows the highest A.I. of 4.16. 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 (Yan, 2008).

According to Yan (2008), when modelling the proposed project in 3D and electronically integrating the 3D models, most of design conflicts are identified and other's 3D models as they design before execute the construction. Typically, many conflicts are undetected until they are encountered during installation and often resulting in expensive rework. Productivity is significantly improved with visualization supports when most of designs conflicts/error are identified and resolved before execute the construction. The researcher mention superintendent of general contractor for Camino Medical Group Project located at California as research respondent explains that he never experienced this level of accuracy with 3D modelling supports in his 35 years of experiences. He estimates that he normally used to spend 2 to 3 hours per day dealing with construction issues on past projects, but he only spent a total of 10-15 hours over an eight months period after the MEP installation began in Camino Project. (Yan, 2008). Notes these issues of construction conflicts often resolved through the Request for Information (RFI) in traditional process. But implementation of 3D in projects for design coordination made it easier to spot and to dramatically reduce the number of design errors and significant reduces Request for information (RFI).

3D models create collaborative project management context among subcontractors whose interests are often conflicting with each other. It is because subcontractors are able to see potential consequences of actions prior to taking them in a 3D environment (Tollefsen et al., 2010). The designs are coordinated and conflicts are identified early in the construction process (as described above). The MEP subcontractors are responsible for the detailed design of their scope of work, able to work out how the components would fit together and how the building systems would interface by creating detailed 3D models in the design phase (Ku et. al, 2011).

4.3.1.5 Reduce Risk Mitigation

Based on the Average Index (A.I.) value, factor B7 which is easy maintenance of building life cycle shows the highest A.I. of 4.12. 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 (Ku et. al, 2011).

Cost overruns or unexpected costs that owners are often faced have forced them to go over budget or cancel the project. Surveys of owners indicate that up to two-thirds of construction clients report cost overruns (Ku et. al, 2011). Quantity surveyors cite insufficient time, poor documentation, and communication breakdowns between project participants, specifically between owner and estimator, are the primary causes of poor estimates (Eastman et al, 2011). Owners and estimator are struggling to respond the design and requirement changes and understand the impact of any changes orders on the overall project budget and estimate (Eastman et al, 2011). By linking the BIM model with the estimating processes, the project team can speed up the quantity take off and overall estimating process and get faster feedback on proposed design changes (Eastman et al, 2011). For example, the quantity take off of case study building can automatically derive accurate quantities and in turn streamline and verify estimates of designers and subcontractors. The accurate and computable nature of BIM provides a more reliable source for owners to perform quantity take off and estimating and provides faster cost feedback on design changes (Eastman et al, 2011).

Table 4.6 Structural framing material take off generated from Revit software

Source Yan, 2008

Structural Framing Schedule			
Count	Family and Type	Volume	Structural Material
M_Concrete-Rectangular Beam: 200 x 450			
1	M_Concrete-Rectangular Beam: 200 x 450	0.39 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.52 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.52 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.36 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.65 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.68 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.15 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.50 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.59 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.63 m³	Concrete, Cast-in-Place gray

1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.51 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.33 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.48 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.51 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.33 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.48 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.51 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.33 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.70 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.51 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.33 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.19 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.51 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.33 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.70 m³	Concrete, Cast-in-Place gray
1	M_Concrete-Rectangular Beam: 200 x 450	0.52 m³	Concrete, Cast-in-Place gray
65			

4.3.2 Challenges and Barriers of BIM Implementation

4.3.2.1 High Cost to Install BIM Tools and Software

Based on the Average Index (A.I.) value, factor T1 which is high cost to install BIM tools and software shows the highest A.I. of 4.22. The quantitative value suggests that this factor is the most critical one. This is also in line with one of the interviewee response that the price of the BIM tools or software is too high. Besides, the price of the license is also very high that not every company can afford it. So, it is challenge for those small-medium companies to adopt the implementation of BIM for the moment.

In addition, the literature also states that high cost to acquire BIM tools or software is one of the main challenges in the implementation of BIM. According to Ku et. al. (2011), software related issues become one of the most important factors when ask about barriers to implement BIM in future areas.

As the use of BIM has its own costs, it comes with rewards. Depicted in the figure 4.4, 40.9% of the respondents stated that the BIM use increased the profitability of the project. Others BIM user may not feel change in profitability of the project and might think that the BIM's advantages do not pass beyond marking, design and visualisation efforts. The first time users of the BIM may feel a negative impact on their profitability due to a new investment in technology and learning curve that comes with it. The consistent participants of the BIM are likely to reap the benefits of BIM and notice increase in their profit. Lastly, the majority of the participants also indicated that the use of BIM reduced cost and schedule of the project. Overall, the cost of the BIM and its supporting technologies can be expensive to begin with. However, the powerful uses of BIM increases profits, lowers costs and scheduling time.

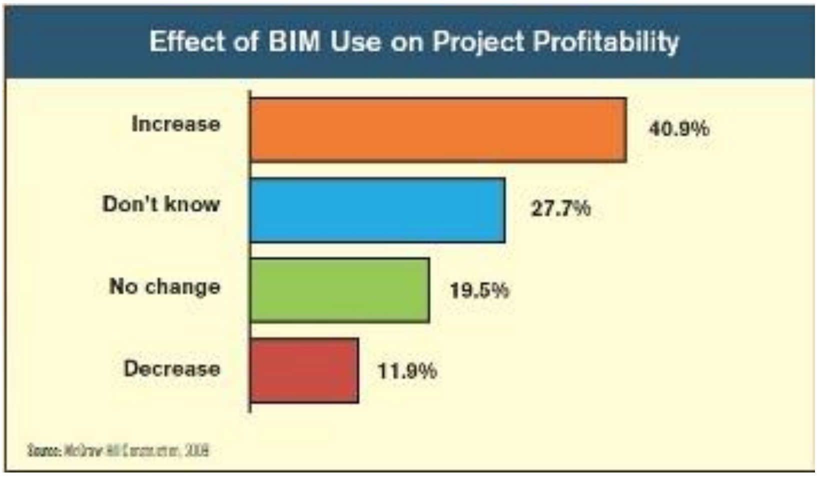

Figure 4.4 Effect of BIM use on project profitability

Source: Larson, 2008

4.3.2.2 Lack of Collaborative Work Processes and Modelling Standards

Based on the Average Index (A.I.) value, factor PR7 which is lack of collaborative work processes and modelling standards shows the A.I. of 4.22. This factor also ranked top ten among all the other challenges. According to the simple interview that being conducted, interviewee claims that the former working process is different with the BIM process. Besides, there is also lack of standards or guidelines for the new BIM process. It is hard to follow the BIM process when there are lack of collaborative working processes and modelling standards.

The implementation of BIM can provide great benefits, this changes however, require a substantial change of the traditional ways of working (Arayici et al. 2009). The basic BIM concept of a single integrated model for the whole project life-cycle needs to be developed in the collaboration setting where multiple project participants are able to contribute (Gu and London 2010). Simultaneously, efficient multidisciplinary project groups supported by BIM require change in the roles of the clients, architects and contractors, and new contractual relationships and a recognized collaborative process must be created (Rizal 2011).

The new life cycle approach to buildings project that BIM enables, require more integrated collaboration approach. In order to assure sustainability in the project, end user, facility managers, contractor and specialist contractors are needed in the planning and design phases of the project. This reflects the development of changing roles of the project participants and new procurement methods following with BIM implementation. (Rizal 2011)

For BIM to be successful, collaboration from all different stakeholders are needed to insert, extract, update or modify information in the BIM model in the different stages in the facilities life-cycle. This is done to support and the roles of all different stakeholders in the model. Optimally, the model can become a virtual representation of the facility that can be handed over from the design team to the contractor to sub-contractors and to the client. As the central model for all stakeholders in the project the BIM model will evolve as the project progresses. Suggested design solutions or changes can be evaluated compared to the requirements by the client during the whole project. The use of BIM to support cross-disciplinary and cross-phase collaboration opens for new dimensions in the roles and relationships between the projects participants (Rizal 2011)

The most important issues according to Rizal (2011) are:

- The new role model manager
- The use of international standards
- Agreement on access right and intellectual property right
- The liability and payment arrangement according to the type of contract in relation to the integrated procurement

Adoption of BIM will have large effect on the work processes and traditional roles in the industry. This adoption will not be easy for actors uncomfortable will change and firms implementing BIM will have to address issues with how workflows should be redesigned, how staff should be assigned and how to distribute responsibilities (Arayici et al. 2009).

ICT technology is not just a set of technological tools aiming to improve old business processes. It is rather a mediator of innovation that involves re-engineering and creation of business processes and strategies. New processes will have to be adapted by construction organizations in order to benefit from the advantages provided by ICT and BIM enhancement. A great challenge presented before construction organizations is to handle these ICT mediated change processes which are ambiguous. In addition, consequences of implementation are hard to foresee due to an immature level of the users (Arayici et al. 2009)

ICT enhancement will lead to an overall organizational change in routines and practices which requires well thought through strategic planning in the permanent as well as in the temporary organization. As mentioned above new technology adoption creates ambiguous and unpredictable changes in organizational processes and social structures, which are to be led by managers of construction organization (Arayici et al. 2009). In addition, organizations are designed to create stability and predictable conditions to reduce the ambiguity of changing conditions (Rizal, 2011). From this perspective, a crucial and hard task is therefore given to PA who has the responsibility to keep the organization in equilibrium. Therefore, the nature of the organizational structure is contradictory to the PA leading change of new technological enhancement.

A present problem that the PA has to face is that there is no clear guidelines or agreements on how to implement and utilize BIM within construction organizations (Meadati, 2008).

4.3.2.3 Fragmented nature

Based on the Average Index (A.I) value, factor PR1 which is fragmented nature shows the A.I. of 4.22. This make up the third critical factor of challenges that faced during the project implementation. Based on the a simple interview that had been conducted through a phone call, the interviewee claims that each and every party of the construction process, tend to concentrate on their own parts that they involved only without bother the other part of the construction process by the other party. This makes the fragmented nature arise between them.

Meadati (2008) sees this as one of the central barriers to BIM implementation in construction industry and had suggested that a shift in current workflows is required. Meadati (2010) claims that BIM, requires the collaboration, database, integration and commitment of companies to the use of BIM software, and that as these areas are still in a separated and fragmented state, it further limits the effectiveness of BIM.

The fragmented industry are given by the designers, developers, contractors and construction managers that tend to focus on their area and protect their interests in the building. On the other hand, the small companies has the difficulties in order to afford the high cost of initial investment needed for training and the purchases of software that are required offers by BIM services (Yan and Damian, 2008).

Good information exchange and collaboration in construction projects are required between all the involved actors due to the collaborative nature of the industry. Traditionally, this exchange was made in the form of drawings and documents, when moving to adopt BIM new requirements are introduced to ensure effective information exchange. BIM is an interface for information exchange between different phases and actors in the project rather that only a tool in the design phase of the project. Currently the different actors are often using different tools, either from different vendors or specialised for their business. Such different in BIM tools present challenges for information exchange between the different actors because of inadequate or lacking interoperability (Yan and Damian, 2008).

The pursuit of solutions for different professions have progressed by the development of BIM tools. This process resulted in different programs that do not interface well with each other or with advanced project management tools. To fulfil different purposes, the two largest challenges for technology developers in regards to BIM have ended up being interoperability in existing BIM systems and creation of multi accurate models (Yan and Damian, 2008).

The Industry Foundation Classes (IFC) defined by the "building SMART" is the accepted standard for BIM models. IFC is an ambitious attempt in achieving model-based interoperability. A wide range of modelling information is covered which is not limited by the geometry of the objects, but also metadata related to other aspects of the building (Yan and Damian, 2008).

When analysing the level on interoperability in IFC, Yan and Damian (2008) consider it in four different levels.

- Syntax level interoperability: This covers the ability for different tools to successfully parse files without error and interoperate without error.
- File level interoperability: This covers the ability for different tools to successfully exchange files.
- Sematic level interoperability: This covers the ability for different tools to come to the same understanding of the meaning of a model being exchanged.
- Visualisation level interoperability: This covers the ability for different tools to correctly visualise the exchanged model.

The analysis by Yan and Damian (2008) came to the conclusion that IFC has so far achieved relative success in providing interoperability in the file and visualisation level within a subset of domains. Within architectural design, this is the most notable. However, it still faces challenges in situations demanding sematic interoperability. That is also the case when its use in broadened to include more sub-domains (Yan and Damian, 2008).

The width of the domain itself can cause the problem with interoperability in the construction industry as different projects can be range from a small simple house up until a complex and large infrastructure. This breadth has been problematic to IFC and its interoperability because no one tool implements all of its language (Yan and Damian, 2008).

Due to fragmented and collaborative nature of the AEC industry interoperability is an important issue, BIM has many viable advantages over CAD but the ability to share the effective and intelligent building information is critically important (Yan and Damian, 2008).

In order to maximize many of the BIM benefits, BIM enables in regards to productivity and design quality the challenges with interoperability must be addressed (Yan and Damian, 2008).

4.3.2.4 Lack of Knowledge on BIM Implementation

Based on the Average Index (A.I) value, factor P3 which is lack of knowledge on BIM implementation shows the A.I. of 4.20. According to the simple interview that had been conducted through a phone call, the interviewee claims that most of the workers in the company did not attend the class on how BIM is being implemented in construction projects. Furthermore, due to high cost and time are needed to learn BIM makes the owners and workers are not willing to spend and invest their money and time on it. This is the reason why the implementation of BIM is much slower than anticipated.

According to Gu and London (2010) there is lack of awareness of the benefits of BIM is construction project and lack of training on how to implement, apply and use BIM in construction project. There is lack of skilful workers who are experts in applying BIM Love, Rizal (2011). Moreover, according to Gu and London (2010). claim that one of the main changes required in enhancing BIM usage at the project level is the training of workers. This is further studied by Yan and Damian (2008) who is their research on the benefits of BIM implementation, the AEC industry also lack of BIM implementation and its application knowledge.

In order to educate personnel and workers the implementation of BIM, a primary organizational factor and essential for successful implementation (Howard and Bjork, 2010). It is important to provide an adequate employee support and efficient training on BIM software, application and implementation to support them on applying the new technology in the future rather than the traditional ways (Gu and London, 2010). It is also important to ensure that the awareness of BIM implementation can be arise among the actors in construction project. According to Howard and Bjork (2010), a new organization may be required as they may promote the use of BIM and spread the knowledge to the others and ensure that the effectiveness of BIM can be enjoyed by the actors in construction industry. A key question posed by them is how this role should be built in and represented within the construction process. Furthermore, to provide sufficient training is on the responsible of the managerial and organizational task. Hence, an environment based on trial and error learning should be created by the managers according to Howard and Bjork (2010). Currently, the problems is to practice such learning and training must be hard due to the economy issue and timeframe that are needed by the owners and workers (Gu and London, 2010). Due to reluctant towards effective implementation is also contributed by the cost associated with relevant training in terms of resources and time wastage. (Yan and Damian, 2008). From this perspective it makes it an important task to the managers to think the most effective way in providing the training session to the workers, as well as to angle the training towards production managers (PrM) that can give the highest return of investment.

It is important in the adoption of BIM that the individuals are sufficiently trained in the use of the new and advanced technology in order for them to be able to contribute to the changing work environment Howard and Bjork (2010). According to Howard and Bjork (2010).The training of personnel are one of the issues that had been discussed most of the time. In order for BIM to be successfully implemented, all the workers must be adequately trained and expert in their respective field (Arayici et al, 2009).

According to Yan and Damian (2008), it is stated that most companies in their research claims that the cost of training is too high in regard of time and human resources. They also claims that the issue of training is also one of the largest barrier of BIM implementation in construction industry. As always, decisions are makes on business perspective, which is to make and gain high profit. AEC industry are not very interested in applying BIM is due to the lack of proven case studies that are successfully managed by BIM due to less time and less cost. Moreover, there are the resistant of changes by the architect due to they are already comfortable and familiar with the traditional ways of managing the project. Hence, they are not interested to change to the new technology. This results in that some actors are not interested in investing and learning on BIM (Yan and Damian, 2008).

4.3.2.5 Lack of Determination of Ownership

Based on the Average Index (A.I) value, factor PR5 which is lack of determination of ownership shows the A.I. of 4.20. According to the simple interview that had been conducted through a phone call, the interviewee claims that there is conflicts arise when comes to ownership of the project and data. As each and every party contributed to the project, the hope that they can own the data. At the end, it is hard to decide who is actually owns the data and project.

Copyright laws and other legal channels are needed to protect the BIM data. Hence, it makes this challenges is one of the most barriers in the implementation of BIM (Azhar et al (2012). For example, the owner paid for the design and data, then the owner may feel entitled to own it, but if the team member are providing information for the project, their information should be protected as well. Therefore, there is no proper answer for the question of the ownership of the data and project which it requires a unique response for every project depending on the participants' needs. The goal is to avoid inhibitions or disincentives that discourage participants from fully realizing the model’s potential (Azhar et al (2012). The best solution is to set forth in the contract documents ownership rights and responsibilities to prevent disagreement over copyright issues (Azhar et al, 2012).

A prerequisite for effective BIM adoption should be in collaboration project environment where interoperability issues are solved. In this environment, processes of mutual information sharing and distribution through BIM contribute to several beneficial aspects (Azhar et al, 2012). In the other hand, this also poses a challenge upon who owns the right to valuable information such as design input information, simulation diverse analysis information and the actual BIM model (Azhar et al, 2012).

Moreover, a possible legal concern is not only focusing to the owner rights of information. Division of responsibility for maintaining and updating the information in the collaborative designed model is one of another present risk (Azhar et al, 2012). Due to the designers and contractors are not willing to take responsibilities on the accuracy of information if the contractual establishment are not supportive or understood, it cause challenge to this posed risk (Azhar et al, 2012).

There is a need of establishing guidelines for a contractual agreement in order to cope with any problems or issues stated earlier. At the present stage of development, professional groups such as Associated General Constructors (AGC) and American Institute of Architects (AIA) are developing contractual guidelines that can address legal concerns related to collaborative use of BIM (Yan and Damian, 2008).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

After this research had being conducted through the reading through literature review and analysing and describing the data obtained from the questionnaire survey, the final stage of this research is to 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.

In this chapter, the researcher will conclude and analyse all the data that had been collected based on the aimed objectives. This is important to check either the all the steps that had been done is achieving its objectives. In the other hand, recommendation and research limitation will be explained.

Basically, this research had being done to study the challenges and barriers of Building Information Modelling (BIM) implementation in construction industry. In this research, the research had analyse the concept of BIM, its function, benefits and challenges of the BIM implementation in construction industry.

Furthermore, the methods to gain the information about this research had been done by literature review, questionnaires and simple interview. Literature review had been done through the reading of journal, articles, books and newspaper. The sources from Internet also had been gained in order to complete the literature review section. Moreover, a series of activities had been done to collect the data from questionnaire survey method. Firstly, the questionnaire form had been designed and questions had been created through the reading of literature review. Next, the chosen of respondents had been made which are contraction firm, consultant firm and architecture firm. Finally, the all the data had been collected and managed.

After the data had been well managed, analyse of data had being done. The data had been analyse by the Average Index (AI) method. All the results had been explained in Chapter 4 which is the discussion on the results. All the graph, chart and table had been explained in that chapter. The next chapter had discussed either the objectives of the research that being done had been achieved or not. Lastly, the conclusion and recommendation will be explained.

5.2 ASSESSMENT ON RESEARCH OBJECTIVES

In Chapter 1, several objectives had been outlined to achieve the research study which is to identify the challenges and barriers of Building Information Modelling (BIM) implementation in construction industry. In order to achieve this, all the objectives had been identified and will be explained later.

5.2.1 Objective 1: To identify the types of challenges from relevant literature review related to BIM.

This objective had been achieved through the sources from literature review. section. Generally, there are three main categories that contribute to the challenges and barriers of BIM adoption in construction industry, which are: people, technology and process.

The implementation of BIM is depending on the people, technology and the environment. People and process are the key for improvement and changes, while the working environment and IT infrastructure are enablers without which the first two elements cannot be sustained.

Previously in the market, there are too many research devoted to BIM is focused on developing technological solutions and technique that is aimed to be the standard and guideline to adopt the design, construction and operational phases of the building. However, recently a successful and completed research had been done indicates that there is range or scale in determining the success of BIM adoption in construction industry. It is found that these behaviours collectively resulted in the formation of the differentiated project team culture, sub-optimal the usage of IT and minimal utilization of BIM capabilities

Hence, the intention to adopt the BIM technology always have to come first before the adoption process begins. For instance, the top management's has the intention to adopt with the BIM technology which it will become the indicator of their subsequent decisions (behaviour). Therefore, it can be conclude that the top management or executive is the one who is responsible for the intention to adopt the innovation from the initial stage with the belief that this innovation have huge potential gains and benefit to them.

Moreover, the organization with appropriate existing technology may adapt the new innovation in IT easily compared to those who are don't. Additionally, they also revealed that the organization 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, characteristics of the industry and project, individual's resistance to change, it is also related to the risks involved in the transformation, the uncertain outcome of the new technology and et cetera.

5.2.2 Objective 2: To design the questionnaire on the challenges and barriers during the implementation of BIM.

Next, the second objective also had been achieved which is to design the questionnaire survey form on the challenges and barriers during the implementation of BIM. All the questions had been created based on the reading from literature review itself. All the questionnaires had been distributed to 50 companies including construction company, consultant firm and architecture firm in Klang Valley area.

A series of activities had been done to collect the data from questionnaire survey method. Firstly, the questionnaire form had been designed and questions had been created through the reading of literature review. The questionnaire survey had been designed to collect the quantitative data for this research and will be distributed to the local construction organisation. This questionnaire consists of three sections, which are Section A, Section B and Section C. Section A is basically about the respondent's background. For Section B, identify the benefits of BIM implementation in construction industry. For Section C, identify the challenges and barriers of BIM implementation in construction industry. After the questionnaire had been collected, all the data will be gathered, computed, and analyse.

5.2.3 Objective 3: To analyse the effect of challenges to the outcome of BIM.

The last objective also is successfully achieved which is to analyse the challenges and barriers of BIM implementation in construction industry. Generally, the identified barriers and challenges based on the analysis that marked the highest ranking in the people issues are professionals resistant to change, lack of knowledge on BIM implementation and lack of proof of the benefits of BIM. While, in technology issues the highest barriers are high cost to install BIM tools and software, liability and intellectual properties and current professional indemnity insurance terms. Lastly, for process issues are fragmented nature, lack of determination of ownership and lack of collaborative work processes and modelling standards.

It is observed 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 should be noted that there is no perfect software application that is capable of containing of all the information created about the whole life cycle of a building. BIM is a specialized tools that are 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 users as it becoming more and more important in the future.

BIM often are interested individuals rather than a whole organization striving towards economic goals. If the understanding of BIM and its possibilities is not well established in the organization there is a risk of losing the goal of why BIM is adopted. Many potential benefits of BIM stem from enhancing collaboration, if there is no common understanding of what the models are going to be used for there can be problems in developing the correct models.

The lack of common agreement on a definition of BIM makes the concept vaguer. Depending on the type of actor the expectations on what BIM is differs. Because of the collaborative aspect of BIM this can be problematic as all actors must corporate in the development and usage of these models. For BIM to be adopted successfully, all actors in the project must participate in this change. Therefore there is a need for ability to make requirements regarding how BIM is supposed to be used. If a single actor is not contributing, much value in the models is lost because of the following inability to use them as intended.

5.3 CONCLUSION

In conclusion, in order to improve the implementation rate of BIM, it has been argued that the actor who should drive the development towards BIM is public clients. Project owner are generally the actor in the project in the best position to put pressure on other project participants to follow the new processes needed. Generally public clients also have both a long term perspective in their projects as well as many consecutive projects.

This enables them to benefit from experiences in earlier projects. It can also be argued that these public actors have a responsibility to make their experiences public, for the benefit of the whole industry as higher productivity in the AEC-industry has socioeconomic benefits.

5.4 RESEARCH LIMITATIONS

Basically, there are some limitation 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 50 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 respondent which more focus on the consultant or contractor or architecture will make the result and analysis of this research bias towards their opinion. Thus, the result of the comparison will become unfair and inaccurate.

Except from that, respondent level of understanding BIM implementation need to be balanced by the 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 experiences in this industry also will make their answer or point of view more reliable and thus the analysis also.

5.5 RECOMMENDATION FOR FUTURE RESEARCH STUDY

The subject of BIM is continuously under study. Based on this study, the following could be possible for further research that may be also beneficial to the industry:

- To develop a more appropriate system in solving interoperability issue in the context of the local construction company.
- 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

REFERENCES

AIA Knowledge Resources Staff. (2008). Contractor Uses BIM to Maximize Profits. AIA Best Practices.

Arayici, Y.,Khosrowshahi, F., Ponting, A. M., & Mihindu, S. (2009). "Towards implementation of building information modelling in the construction industry".

Azhar, S et al. (2012) 'Building Information Modelling (BIM): Now and Beyond', *Australasian Journal of Construction Economics and Building*, 12 (4) 15-28 – Salman Azhar, (Auburn University, USA) Malik Khalfan and Tayyab Maqsood.

Bansal, V. K., & Pal, M. (2009). Construction schedule review in GIS with a navigable 3D animation of project activities. *International Journal of Project Management*, 27(5), 532–542.

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. Building* (Vol. 2).

Gu, N., London, K. (2010) "Understanding and facilating BIM adoption in the AEC industry." *Automation in Construction*, 19 (8) (2010), pp 988-997.

Grilo, A., & Jardim-Goncalves, R. (2010). *Automation in Construction*, Building Information Modelling and Collaborative Working Environments, 521.

Haron, A.T. (2013). *Organizational Readiness to Implement Building Information Modelling: A Frameworkfor Design Consultants in Malaysian*. School of Built Environment, The University of Salford, Salford Quays, U.K.

Hartmann, T., Gao, J., & Fischer, M. (2008). Areas of Application for 3D and 4D Models on Construction Projects. *Journal of Construction Engineering and Management*, 134(10), 776–785.

Howard, R., Bijork, B. C. (2008). “Building Information Modelling-Experts” views on standardization and industry deployment”. *Advanced Engineering Informatics*, 22(2), 270-290.

Jardim-Goncalves, R. (2010). Automation in Construction. Building Information Modelling and Interoperability, 386-388.

Jung, Y., & Joo, M. (2011). Building information modelling (BIM) framework for practical implementation. *Automation in Construction*, 20(2), 126–133.

Kacprzyk, Z.,(2014). Building information modelling-4D Modelling technology on the example of the reconstruction stairwell. In *Procedia Engineering* (Vol. 91, pp. 226–231).

Kiviniemi, A. (2013) “Public clients as the driver for open BIM adoption-how and why UK government wants to change the construction industry?” *Conference at Clareon Hotel Airlanda airport, Open BIM*. 2013-04-22.

Ku, K. and Taeibat, M. (2011) ‘BIM Experiences and Expectations: The Constructor’s Perspective’. International Journal of Construction Education and Research, 7 (3), 175-198.

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

Larson, D. A. & Golden, K. A. (2008). Entering the Brave New World: An Introduction to Contracting of BIM. William Mitchell Law Review.

McGraw-Hill Construction. (2008). BIM: Transforming design and Construction to Achieve Greater Industry Productivity. Smart Market Report.

Meadati, Pavan, Javier Irizarry, and AminK. Akhnoukh. “BIM and RFID Integration: A Pilot Study.” Advancing and Integrating Construction Education, Research and Practice (2010): 570-578. Georgia Institute of Technology. Second International Conference on Construction in Developing Countries, Aug. 2010. Web. Oct. 2010. <conectech.coa.gatech.edu>.

NAP, T, N. (2009). Advancing the Competitiveness and Efficiency of the US Construction Industry. Washington: National Academy of Sciences.

Navendren, D., Manu, P., Shelbourn, M., & Mahamadu, A. (2014). Challenges to building information modelling implementation in UK: *Designers' perspectives*.

Post, Nadine M. "Building Team Views Technological Tools as Best Chance for Change." Engineering News Record. Nov. 2008. Web Nov. 2010. <enr.com>.

Stelth, P., & Roy, G. Le. (2009). Projects' Analysis through CPM (Critical Path Method). *School of Doctoral Studies (European Union) Journal*, (1), 10–51.

Sulankivi, K., & Kähkönen, K. (2010). 4D-BIM for construction safety planning. *Proceedings of W099- …,* (May), 117.

Tulke, J., Nour, M., & Beucke, K. (2009). Decomposition of BIM objects for scheduling and 4D simulation. *Ework and Ebusiness in Architecture Engineering and Construction*, 653–660 736.

Udom, K. (2012). BIM: mapping out the legal issues. Retrieved from http://www.thenbs.com/topics/bim/articles/bimMappingOutTheLegalIssues.asp

Yan, H., Damian, P. (2008). "Benefits and barriers of building information modelling". In 12th International Conference in Computing in Civil and Building Engineering 2008.

Yazici, Oguz C. 'BIM, Scheduling and RFID." Personal interview. Sept 2010.

Young, N W., Stephen, A. J., Harvey. M. B., and John E. G., "Research 2". Smart Market Report: The Bussiness Value of BIM (2009): 8-11.

APPENDICES

APPENDIX A- QUESTIONNAIRE SURVEY FORM

FACULTY OF CIVIL ENGINEERING AND EARTH RESOURCES

QUESTIONNAIRE FORM

TITLE:

CHALLENGES AND BARRIERS OF BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION IN CONSTRUCTION INDUSTRY

PURPOSE:

This survey questionnaires form is distribute purposely for research related to the challenges and barriers of Building Information Modelling (BIM) implementation in construction industry. All information given will be **CONFIDENTIAL** and purposely for research only.

RESPONDENT:

Construction Company and Consultant Firm in Klang Valley

STUDENT INFORMATION:

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