THE IMPACT OF BUILDING INFORMATION MODELING (BIM) TO
ARCHITECTURAL DESIGN PROCESS

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ABSTRACT

Design in architecture is one of the most diverse activities considered by all related parties in construction industry. During the construction design process, many problems and errors such as design changes & rework, incomplete design, standard of quality in drawings and technical specifications, lack of communication, delays in the drawings, mistakes and errors are arising from this industry day by day. This research has been conducted with the aim to establish the contribution of Building Information modeling (BIM) on architectural design process. The objectives of this research includes, to recognize and examine the current conventional design problems in construction projects in terms of time, cost and quality and to recommend the benefit that is obtained by using BIM technology in the architectural design process. This research was conducted by using qualitative method where experience architects whom are currently implementing BIM in their firms was been interviewed. The feedback and results obtained from the interview were analyzed by using Microsoft Excel. Quota sampling method was used in selecting the respondents, which consists of 8 architects implementing BIM. The analysis results shows that, architect realize the problems and suggested the solutions based on their experience in handling several of projects by using the conventional method. It also shows that, BIM is the future tools for 3D design since it integrate all the design documents, the drawing are well interpreted and the designer easily viewable compared to conventional method. It is important, architects need to present their design in 3D drafting to create a better visualization to the client. Adoption of BIM should be implemented from the early process in order to manage construction project effectiveness.
ABSTRAK

Rekabentuk adalah salah satu aktiviti yang paling penting dititikberatkan oleh semua pihak yang terlibat di dalam industri seni bina. Semasa fasa pembinaan, kebanyakan masalah yang sering berlaku seperti perubahan rekabentuk dan perbaikan semula, rekabentuk yang tidak lengkap, tahap kualiti lukisan rekabentuk dan spesifikasi teknikal, kurang komunikasi, kelewatan dalam penyiasan lukisan dan kekangan yang meningkat dalam industry ini dari masa kesemasa. Tujuan kajian ini adalah untuk mengenalpasti kebaikan penggunaan “BIM” dalam proses rekabentuk pembinaan. Objektif kajian ini adalah untuk mengenalpasti masalah yang wujud di fasa rekabentuk dalam sektor pembinaan yang sedia ada dari segi masa, kos dan kualiti serta mengkaji cara pengurangan masalah dalam fasa rekabentuk dan mencadangkan faedah yang boleh diperolehi melalui pengaplikasian “BIM” dalam fasa rekabentuk bangunan. Kaedah metodologi yang digunakan dalam kajian ialah melalui pendekatan kualitatif. Maklum balas dan keputusan yang diperolehi melalui temubual telah dianalisiskan dengan menggunakan “Microsoft Excel”. Kaedah persampelan kuota digunakan untuk memilih responden arkitek seramai 8 orang yang menggunakan “BIM”. Hasil kajian telah menunjukkan pihak arkitek menyedari dan memberi cadangan mengikut pengalaman mereka dalam pengedalian sesuatu projek pembinaan dengan menggunakan sistem konvensional. “BIM” adalah alat rekabentuk maya 3D masa depan kerana ia dapat mengintegrasikan semua maklumat projek serta boleh dipraktikan dalam sektor pembinaan berbanding dengan sistem konvensional yang sedia ada. Cadangan kajian ini adalah, arkitek perlu membentangkan rekabentuk mereka didalam paparan 3D supaya pelanggan dapat memahami reka bentuk tersebut. “BIM” seharusnya dilaksanakan dari proses permulaan supaya pengurusan efektif projek pembinaan dapat dilaksanakan.
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CHAPTER I

INTRODUCTION

This chapter provides general introduction for this thesis. It begins by discussing the subject matter of the research by highlighting the main issue under exploration and providing a background to explain it. This aspect culminated in the problem statement of the research. The next main section addresses the purpose of the thesis by explaining the main aim and objectives of the research. It also outlines the key research questions that guided the inquiry. The next section indicates the scope and limitation of the thesis. It describes the key elements considered in the research and the geographic area to which the research is confined. It then indicates the limitations of the research in terms of time and those relating to data collection. This followed by briefly addressing the scientific relevance, applicability, societal relevance and use and the methodology of the research. Finally, the organisations of research was described.

1.1 Background of Research

Rapid growth of construction industry in Malaysia becomes one of the major industries contributing significant growth to socio-economic development. The Architecture/Engineering/Construction (AEC) industry is one of the multidisciplinary domains in which collaboration among related parties is of utmost importance. With the advent of computers, many material and technological improvements have been made to building design in the last four decades and many builders and designers saw their drafting load lightened because repetitive tasks could be automated. After six centuries of manually conveying lines and texts on
paper, computers were first adopted as an aid for automating certain aspects of the design process to Computer Aided Design (CAD) systems which generate digital files. Though, conventional two-dimensional (2D) CAD technology has dominated the industry, and technological progress has been severely constrained by the limited intelligence of such applications in representing buildings and the capability to extract the relevant information from the representation that is needed for building design. Drawings are no longer done manually, but the ubiquitous use of CAD applications in creating drawings has not revolutionized the construction industry in any way. With the automation of design tasks using computers, the essential nature of documentation did not change. The same drawings and documents describing the project are still used.

Architectural design is a complex and open process. Design process starts from the abstract stage to solve a design problem until it reaches the design solution in the form of design product. Designing activities is a repetitive problem solving process (Demirkan 1998). Watanabe (1994) describes designing process as a process to fulfill human needs through new idea produced. According to French (1998), architecture design is a response to human special needs which is refuge and comfort. Lawson (1997), states that architectural design is a process where an architect produced a space, place and building which has a big amount of effects on the quality of human life. Most architects agreed with Sanders (1996) whom stated that architectural design is a repetitive process where the process scheme can be recognized, valued, repeated, explored and repaired until the best solution is achieved. Decision making activities in architectural design process happens at sketching stage, schematic design stage and final design stage. At the details stage, design process is focused on producing drawings activity and planned building construction activity.

Currently, the work within the design process is split into several temporary sequences, and it is delivered to different specialists for its execution. In building projects, first the owner selects the architects who prepare the architectural designs and specifications, then the structural design and other specialty designs are developed. Generally, in construction stage, a contractor selected by the owner, and it is deliver to different consultants for its execution.
As mentioned by Saputra et al. (2011), the time, cost and quality are the main indicators in measuring construction project success. An assessment needed to measure the capability to meet these three constraints before a project started. The management can set up a set of action plans in the planning and design stage as preventive or response based on the assessment results. It is in the design process where the requirements of the client are identified and the constructive aspects and the standards of quality are defined through procedures, drawings and technical specifications.

Nowadays, the AEC (Architecture-Engineering and Construction) industry is facing a technological change represented by the transition from CAD-based (Computer Aided Design) documentation to BIM (Building Information Modeling). Unlike the CAD drawings which were limited in information, BIM opens an expanded range of possibilities due to the immense amount of information which can be encapsulated and later extracted from the digital model. BIM involves representing a design as objects that carry their geometry, relations and attributes (Eastman, 2009). In addition, separate drawings for contract documents and then developing a separate set of detail drawings are consider waste.

BIM not only helps to reduce this waste and inefficiency but also helps in reducing the potential for litigation. It changes the base documentation used in building design and construction to a new representations, which are machine readable for automation as opposed to human readable for manual conducts (Smith et al., 2009). Figure 1.1 shows the contents of building designs are transfer from paper to digital 2D-CAD-drawings during the 1990's. Currently we are experiencing a change from drawings towards model based technology and methods. The models produced are more friendly then conventional method. Therefore, BIM adoption is increasingly important in the construction industry (Penttila, 2009).

Therefore, this research is focus upon what is the impact of BIM on the architectural design process.
1.2 Problem Statement

Due to the fragmented and complex nature of construction, many problems could arise every day during the construction process caused by factors such as weather, material delivery delay, labor dispute, equipment breakdowns, job accidents, change orders, and numerous other conditions. Most of the people involved in the construction project lack communication and less interaction among the project teams directly contribute to the problem. The earlier the changes are rectified, the lesser impact it will have on the project. Furthermore, conflicts over project changes can be minimized when the problem is found at the earlier phase of the project.

During design stage usually, planners and architects work independently with little input and lack of communication with each other (Granroth, 2011). Due to this, revisions of plans and designs always occur that affect government and the private are required to have a close collaboration and working together to bring positive changes in the industry. Lerthlakkhanakul et al. (2008), and Autodesk (2008), state the dependency between project platforms and technical platforms saying that there is a gap in communication between architects and users. The architect fails to explain
his or her design how the design will look like after users are unable to imagine how the design will be emerged after the construction phase. In the related literature, it is also well documented that there is a lack of integration between the current computer aided design (CAD) systems (Taslı and Sagun, 2002; Hew et al., 2001). Most of the practical and exploratory CAD tools focus on single discipline or a single task in the process. Therefore, the usefulness of models should be judged not against an imaginary perfection, but in comparison with the mental and descriptive models that could be used alternatively (Radford et al., 1988).

The problems of this work sequence have been discussed for many years. The main problems that have been detected are the little interaction among design and construction and among the specialists, this situation compels the following phases to work on incomplete designs. The consequences are suboptimal solutions, lack of constructability and a great number of change orders (design and construction rework). The impacts of changes are not understood and rarely recognized, in terms of costs and schedule. The work hours invested by the designers in the changes have been estimated in a 40 to 50% of the total of a project (Koskela 1992). In Latin American countries, it is estimated that between 20 to 25% of the total construction period is lost as a product of design deficiencies (Undurraga 1996).

On the other hand, the problem with the traditional/conventional method is that the documents produced are same as manual and did not save the building design and construction industry from being inefficient. CAD systems did nothing to reduce errors and wastages which basically arise due to coordination problems. Though, as CAD systems were further developed, additional information was added to these systems to allow for more data and associated text. With the introduction of conventional three-dimensional (3D) modeling technologies, advanced definition and complex surfacing tools were added. Based on the previous argumentation it is clear that the design-construction interface offers a great potential for improvement.

To overcome the limitations of traditional 2D designs, BIM which is a novel technology and concept has solved many issues related in design process. To achieve this improvement it is necessary to recommend BIM technology and its benefits which have been playing a major role in improving time, cost and quality in design process.
1.3 Aim of the Research

The aim of this research is to establish the contribution of BIM on the architectural design process.

1.4 Research Objectives

The objectives of this research are:

i. To recognize and examine the current conventional design problems in construction projects in terms of time, cost and quality.

ii. To recommend the benefits that can be obtain by using BIM technology to establish the impact of BIM on the architectural design process.

1.5 Significance of the Research

Today we are in a highly competitive world as far as project performance is concerned. There is a need for construction innovation. Therefore, putting multiple efforts in vastly integrated and complementary ways to achieve this construction project success is required. This research will contribute to architects in particularly on how designers can improve their work faster, effective and quality during the design process, and identify how BIM technology can be apply in projects to realize the impact of BIM on the architectural design process. The result from this research will be useful to architects to practice the impact of BIM in early stage. The research concluded that, although BIM technology do pose some shortcomings such as interoperability issues, the use of BIM is beneficial to the construction stakeholders.
1.6 Scope of the Research

Project success is dependent on, the performance of the design team. The designers are the key players in the construction industry whose services are need from the conception stage of the project to its completion. The performance of the designers is therefore important because any decision made at the inception of the project will affect project success. According to Minato (2003), defective designs adversely affect project performance and the participants and are responsible for many construction failures. Failure at the conceptual planning and design stages may lead to significant problems in successive stages of the project. Therefore, this research concentrates on the design stage, focusing on architects in three triangle (time, cost and quality) practices. This research focuses on the participants of the construction industry, which is an architect to get their opinions towards the BIM adoption in solving the construction projects success issues. The respondents were chosen based on the top management level and the middle management only. In addition, the research will only focus on the construction firms that using BIM.

The major limitation is that the interview of this thesis is focusing on Malaysian architects firm which is regarding the use of BIM practices. Thereby the majority of architects have limited knowledge and limited practical experience on BIM issues. To set a realistic and interesting scope for this project, it was been chosen to do interviews on the design process only.

1.7 Research Methodology

This chapter describes the methodology used in this research. In this study a qualitative research method was applied and is built up by a relatively small number of semi-structured and open-ended interviews (Silverman, 2005). The qualitative method is used when there is a wish to describe things that already exists. It started by conducting the first stage of the literature review. The goal of this research methodology was to collect qualitative data that could be used to compare against findings from other research strategies. It is important to note that this research engaged two stages of literature reviews. The first stage of the review carried two
purposes as following: This approach is expected to understand and deliver the interviewees’ experience, attitudes, and best practice to implement BIM in construction projects. Both Trost (2005) and Silverman (2005) emphasize the view of the reality as complex and our choice of study method as not always obvious.

After defining the interview questions and the data collection strategy, the research progressed into the data collection stage. The stage was initiated by first identifying potential representative. The identification was done by reviewing the local job advertisements on the internet and in newspapers that offered BIM related posts, direct communication with BIM tools providers, direct contact with participants and speakers in a local BIM seminar and attachment and collaboration with Construction Research Institute of Malaysia (CREAM), the research arm for Construction Industry and Development Board of Malaysia (CIDB). As a result, eight architects were identified and agreed to participate in the case study research.

Eight experts were interviewed. They were selected based on their knowledge and expertise in this field. All of the eight interviewees have a long experience in architectural practice and they are BIM users. The main techniques that were used to collect the primary data were semi-structured interviews each organization. Each interview was audio recorded using a Dictaphone. As for analyzing the data, it was firstly transcribed into an interview script before content analysis was conducted. The findings from each architect were then cross analyzed in a table of matrix form to determine the pattern of answers. After that, the second stage literature review was conducted to make sense, justify, and theoretically validate the research findings. The process flow of the research is described in chapter 3, Research Methodology Framework in Figure 3.1, Research Process Flow, as can be referred to page 64.

1.8 Organization of the Thesis

The organization of this thesis includes the following below;

Chapter I: Introduction
This chapter aims to give an overview of the thesis. This first chapter provides an introduction to the research issue. It presents a general view of the background and describes briefly the main problem and what this research aims to achieve.

Chapter II: Literature Review
This chapter consists of a literature review where major research and other relevant research with regards construction project performance, three triangles (time, cost and quality) and time management are highlight. Authors elaborate the most important parts of related theory found in academic literature and electronic sources.

Chapter III: Research Methodology
This chapter explains about the interview that have been use to carry out this research. The description of each method briefly explained in the chapter. Besides that, explains the technique used in the analysis and issues related to data collection.

Chapter IV: Problems in Design Process
This chapter explains about the first objective for the purpose of this research. Identify the problems of design stage that currently exists in construction projects in terms of time, cost and quality and identify the factors to overcome the problem in construction design stage.

Chapter V: Benefit of Using BIM in Construction Design Process
This chapter consists of the second objective. It will determine the benefits that can be obtained by using BIM technology to achieve construction project success in design process.

Chapter VI: Conclusions and Recommendations
The chapter revisits and discusses the summary of the research, the research objectives, and the research questions, presents the conclusions derived from the research, highlights the contributions, points out the limitations of the study and suggests recommendations for future research. References and appendices are presented at the end of the thesis.
1.9 Summary

This chapter had covered the research topic, clarify the problem statement and emphasise the importance of the research. The research background was first introduce and explains current situation faced by construction industry in design stage at Malaysia. The aim and objective of the research to established as well as the scope and method study. Outline of the thesis chapters were also discuss. On this basis, the research continues with detailed explanations of the research and development process. The next chapter 2 describes the research procedure and techniques that were used literature review of the thesis. Briefly described along with the definition and concept, BIM concept, BIM benefits particular design phases.
CHAPTER II

LITERATURE REVIEW

This chapter is presented the literature; covering research papers, reports, white papers, and books. The review of these studies confirms the previous discussion for the need of detailed studies about the role and use of BIM from the project management point of view. The first subchapter describes the basic information regarding BIM. The second subchapter presents the construction project management in time, cost and quality is more focused on the design process. Finally, the chapter will zoom in on the potential of BIM for project management in particular design phases.

2.1 Overview of the Malaysia Construction Industry

The opportunities and problems in construction are very much from those of the last century. The demands of clients, companies and employees differ from time to time, and thus the vision of the construction industry is always developing; to keep up, management must change too. Based on several researches, it is known that time and cost overruns create a bad image for the construction industry in many countries including Malaysia. As mentioned by Adrian (2004), over the years there have been many technological such as in the construction process that have both increased the rate of construction, and supplemented the complexity of the construction processes. BIM has the potential to develop the construction industry, although it is not without its potential drawbacks, and the benefits of BIM have yet to be documented since it is still relatively new to the construction industry. This research will address the growing need to develop project management in design phase by using BIM, which in turn will help in shaping the goals of the future.
2.2 Definition and Concept

This section discusses the definition and concept of project management, design, Building Information Modeling and BIM concept.

2.2.1 Project Management (PM)

Construction is one of the important sectors, which influence the economy of our country. This sector creates many work opportunities to the citizen and involves several parties such as contractors and architects. According to Kerzner (2006), Project management defined as the short-term objective relatively in planning, organizing, directing and controlling the company resources establishing to complete the specific goals and objectives.

Project management is not much different from construction project management in general; Walker (2007) defined, construction project management as planning, coordinating and controlling of a project from the beginning to completion on behalf of a client demanding objectives. This includes of utility, quality, function, time and cost, and the establishment of relationship between the resources, integrating, monitoring and controlling the contributors to the project and their output, and evaluating and selecting alternatives in pursuit of the client’s satisfaction with the project outcome.

Construction project management is the same main objects as project management which are cost, time and performance, but in construction PM its cost, time and quality as Walker mentioned, which did not change fundamentally but may be taken at a wider range in referring to people and the importance of working through others, also in construction project management client satisfaction is another important key to project success besides the objectives and goals of the company itself. Haynes (2010) defines project management as project management concentrates on a project. A project is an undertaking that has a beginning and an end and is carried out to meet established goals within cost, schedule and quality objectives. Project management brings together and optimizes the resources necessary to complete the project successfully. These resources include the skills,
talents and co-operative efforts of a team of people, facilities, tools, equipment, information systems, techniques and money.

2.2.2 Design

Design in general, and in architecture specifically is one of the most diverse activities done by humans. It been approached in many ways and has been formulated using several principles. It is very hard to define what design actually is (Miles et al., 1994). Design could be viewed as an activity that translates an idea into a blueprint for something useful, whether it is a car, a building, a graphic, a service or a process. The important part is the translation of the idea, though design's ability to spark the idea in the first place should not be overlooked. Good design begins with the needs of the user (Shedroff, 2009).

Details in Figure 2.1 show, the views of the design in different perspective. An architect’s designs could solve a lot of problem in the construction industry, where decision making during this design stage even during presentation of the design stage is very important. Besides then that design also could reduce and fulfilled constraint and direct the designer’s team to meet the objective of their designs. Therefore, designs search of what the client’s requirement and as an early stage of the planning in the construction industry. The most important part of the design is by mapping a functional phase into a physical space.


| Design is satisfying constraints and meeting objectives |
| Design is problem solving |
| Design is decision making |
| Design is reasoning under uncertainty |
| Design is search |
| Design is planning |
| Design is an interactive process |
| Design is a parallel process |
| Design is an evolutionary process |
| Design is a mapping from functional space to a physical space |

Figure 2.1: The Different Views of Design (Miles et al., 1994)

### 2.2.3 Building Information Modeling (BIM)

According to National Institute of Building Sciences (NIBS, 2007), BIM is consider as 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 decision during its life cycle, defined as existing from earliest conception to demolition.

BIM defined as the parametric modeling of a building. Simply stated BIM allows the project team to virtually design and construct the building. BIM is not only a technological innovation, but also a significant shift in the overall design process (Hyatt, 2011). Figure 2.2 shows the trend of BIM tools in architectural, structural and mechanical (plumbing & sanitary) and electrical model.
BIM is a digital representation of the physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder (Smith, 2009).

BIM is not just the latest release of CAD software, it is an entirely new way of looking at the design and construction of a building. It is consider as one of the most promising developments in the AEC industry (Smith, 2009; Eastman et al., 2008) and will become the facilitators of integration, interoperability and collaboration in the future of AEC industry (Isikdag et al., 2008). As architects move more rapidly to BIM, the opportunities to leverage digital design data for downstream building asset and facilities management become more prevalent (Bernstein & Pittman, 2004).

Furthermore, BIM is an innovative new approach to building design, construction, and management introduced by Autodesk (2008), and has changed the way the industry professionals worldwide think about how technology can be apply to building design, construction, and management. BIM supports the continuous and immediate availability of project design scope, schedule, and cost information that is high quality, reliable, integrated, and fully coordinated (Autodesk, 2005).
BIM in its present state commonly used on complex projects such as high-rise buildings, bridges, arts centre, stadiums, and medical facilities. The term is most commonly applied for planning, design, construction, and management of buildings; however, its capabilities are being extended to challenging and complex civil engineering projects. 3D modeling is just another aspect of BIM that has hogged the limelight, but its real strength and power lies in the knowledge database, which can used in conjunction with other software’s to deliver quick and reliable information in areas of sustainability, estimating, structural analysis, demolition and reconstruction (Sah & Cory, 2008).

BIM is beginning to change buildings how they look, the way they function, the ways in which they built. BIM is not a type or a thing of software but a human activity that involves wide process changes in construction. BIM is a philosophy for managing and accessing common building and facilities information. It is apply throughout the facilities life cycle, from requirements definition through disposal. Its goals are to provide installation owners with the best information available for making best value decisions and reducing total ownership costs (TOC).

Advancements in software technology have led a new architectural drafting revolution. BIM software provides an innovative approach to developing a set of construction drawings for a building. Compared to CAD, the BIM software essentially creates a drawing for the user according to the provided input, hence the name, ‘information modeling.’ There are many additional advantages that BIM has over CAD software. CAD drawings are often insufficient to meet the requirements of a model-based design process, as industry expectations for analysis using a model-based approach are expanding (Autodesk, 2008). BIM is more than drawings. It is a data repository for building design, construction and maintenance information combined in one convenient model to share with all the stakeholders (Eastman, 2009).

BIM simplifies the drafting process and at the same time provides additional assets to the drawings. Using one electronic file, an entire set of mechanical, electrical, plumbing and structural drawings can be created from the architectural model (Eastman, 2009). The user generated information can be modified to meet the construction specifications. In other words, every time the user draws a wall, they must declare the composition of the wall section. This includes products, materials...
and sizes. Using this information the software will generate schedules and list of materials with quantity of materials to purchase. This is where the main sustainable aspect comes into play. Limited construction waste is a direct benefit of using BIM software. In the construction industry, tremendous level of coordination is needed in an environment where the collaboration of a number of organizations is crucial during the duration of one project (Alshawi & Faraj, 2002). BIM technology can lead to major productivity improvements by integrating the work of the construction project network (Taylor & Bernstein, 2008).

However, NIBS (2007) notes that, the acronym BIM is used in several different ways shows in Figure 2.3. BIM can refer to:

i. A **product** (*Building Information Model*; a structured dataset describing a building),

ii. An **activity** (*Building Information Modeling*; the act of creating a Building Information Model)

iii. A **system** (*Building Information Management*; business structures of work and communication that increase quality and efficiency).

![Figure 2.3: Different Definitions for BIM (NIBS, 2007).](image-url)
According to Taylor & Bernstein (2008), BIM is a new industry term referring to parametric three-dimensional computer aided design (CAD) technologies and tools to support the work in the architecture, engineering, and construction (AEC) industry. However, in addition to 3D, BIM can also include dimensions of 4D or 5D (Kraus et al., 2007). 4D means 3D CAD drawings with added dimension of time and 5D contains a 3D CAD model with the added dimension of time-based costs (Kraus et al., 2007).

2.3 BIM Concept

BIM is basically a digital platform for creation of virtual buildings (GSA, 2007). If BIM is to be applied in a total sense, a model should be able to contain all the required information to collaborate, predict and make decisions regarding design, construction, operation, cost, and maintenance of a facility prior to construction. “BIM represents a paradigm change that will have far-reaching benefits, not only for those in the building industry but for society at large, as better buildings are built that consume less energy and require less labour and capital resources” (Eastman et al., 2008). No project has yet fully realized the total scope of BIM.

BIM is considered more than just a tool or a technology it represents a whole new way of addressing the building process in current construction practice. BIM facilitates 3D, 4D, 5D, and 6D.

- 3D is object-based parametric modeling
- 4D is sequencing and scheduling of material, peoples, floor space, time, etc.
- 5D includes the part-lists and cost estimates
- 6D considers facilities management, the lifecycle cost, and environmental impacts. These concepts are profoundly depending on software technology in order to be implemented.

According to Words & Images (2009), three variants of BIM implementation in design and construction in progressively more complex and powerful grades are:

**BIM-A** is the lowest level and refers to the use of BIM software to accelerate document production within a design firm. BIM-A currently provides compelling
advantages over conventional CAD for design documentation. Early adopters in large firms report savings of 30% or more in production costs and dramatic increases in profitability.

**BIM-B** is the use of BIM software among partnering firms to take advantage of data exchange opportunities to reduce communication costs. BIM-B is just emerging in trial implementations on a few projects. BIM-B requires close, long-term relationships among architects, consultants, and prime contractors that can justify the standardization of documentation procedures and representations. In theory the value can be very high but in practice there are very strong indicators of effectiveness.

**BIM-I** is the conceptual model of industry-wide adoption of data exchange protocols around standard software interfaces. BIM-I requires widespread standardization of data exchange protocols as well as contractual and tacit agreements to share data. The potential to reduce communication costs, reduce construction waste, expedite schedules and increase quality are difficult to quantify but may be several percentage points of construction cost.

According to General Services Administration (GSA) 2007), the most important letter in BIM is therefore the **I for information**, as this is the revolutionary part of BIM. The sequence of **BIM-A** to **BIM-B** to **BIM-I** is a natural and necessary sequence that likely must be followed by each firm. BIM-B requires a certain internal mastery of software and innovative processes that are representative of BIM-A, while BIM-I requires a degree of familiarity with the data exchange necessary for BIM-B as well as pervasive adoption of BIM technology and data exchange protocols among consultants, contractors, and suppliers.

2.4 **Current Industry Practices in PM**

Construction process can be divided into three important phases; project conception, project design and project construction. A project is a one-time task controlled by time, cost, and quality, and its success depends on how fit these constraints are balanced (Atkinson, 1999). All construction projects comprise two different phases: the preconstruction phase (the period between the initial conceptions of the project to
awarding of the contract) and the construction phase (period from awarding the contract to when the actual construction is completed). Delays and cost overruns occur in both phases. However, the major instances of project overruns usually take place in the construction phase (Frimpong et al., 2003). Before any construction can take place, the contractors usually need to redraw drawings so they are sufficient for construction process. Those drawings are called “general arrangement drawings”. Furthermore, subcontractors make their own “shop drawings” which are ready for production of items like precast walls, steel connections, piping runs, etc. Shop drawings are very precise and detailed. If they are based on drawings which, already contain errors there might be conflicts on the site and costs associated with this issue might be significant. To produce building elements offsite when detailed drawings may not reflect real situation onsite is not rational solution. Therefore, most of the fabrication has to take place onsite where all conditions are known. This, however, is more costly and time consuming; quality control of produced elements is not as good as it is in factory. In fact, the nature of the construction process is such that it requires the timely exchange of appropriate, adequate and accurate information. It is between the client and design teams during the brief, design interface in terms of the brief, feasibility studies and sketch plans, and the design and building teams during the design/construction interface in terms of the working drawings, schedules, bills of quantities and specification.

2.4.1 Time, Cost and Quality

Management in the construction industry is considering as one of the most important factors affecting performance of works. In the industrial world and construction industry in particular, time, cost and quality form a triangular relationship (Figure 2.4). In the majority of decision making parts, management has to compromise in one area in order to get the best result in the other two. Mainly, “Cost” and “Quality” are always fighting for “Time” (Saputra, 2011).
2.4.1.1 Time

Timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants similar. Successful companies must deliver projects on time, within budget, and meet specifications while managing project risk (Raymond & Bergeron, 2008). In construction, delay could be defined as the time overrun either beyond completion date specified in a contract, or beyond the date that the parties agreed upon for the delivery of a project.

2.4.1.2 Cost

A mentioned by Azhar et al. (2008) in his research “Cost is among the major consideration throughout the project management life cycle and can be regarded as one of the most important parameters of a project and the driving force of project success”. Furthermore, cost performance is an effective technique in project management effort expended and it is widely accepted in the literature and industry (Gido & Clements, 2003).
2.4.1.3 Quality

According to Flanagan & Tate (1997), quality of the finished project one of the components that contributes to “value for money” to the client. Vincent and Joel (1995) define, total quality management as: “…the integration of all functions and processes within an organisation in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction.”

2.4.2 Time Management

Realistic ‘construction time’ has become increasingly important because it often serves as a key benchmark for assessing the performance of a project and the efficiency of the contractor (Kumaraswamy & Chan, 2002). According to Samuelsson (2008), the use of technology that can handle 3D computer object has doubled by architects and increased with over 30% by technical consultants (Figure 2.5).

Figure 2.5: Usage of Technology to Produce Model in 2007 (Samuelsson, 2008).
In the current situation, all participants in the project use a common database to store drawings and exchange information with each other (Bergmark, 2004 & Noren, 2009). In conventional method (2D) “plain old” hidden lines views but in Revit Architecture colour settings done and leaving the visualization studio to focus on the high quality presentation material needed for reviews, approvals and marketing the project save time. The platform from Revit linked to the visualization of 3D StudioMax that minimizes the time required to coordinate the architectural design and visualization (Autodesk, 2008).

2.4.3 Cost Management

Angelo et al. (2002) pointed out that, cost overrun is a main problem in project development and is a regular feature in the construction industry but it is not as much of effective compared to time management (Ramli, 2003). Categories of project cost management include project resource planning, cost budgeting, cost control and cost estimating. Two important components of cost control are cash flow management and project accounting. It should determine the projected final cost and consider the projections of future cost where it involving scope, time and quality. Normally, cost estimation made before the start of a project so that it can be control within cost budget. A project may require more than one person and may occur more than once during the life of a project which, depending on the complexity of the project. It may be very simple or extremely complex when managing the cost of project. In project management, it should also consider the needs of project stakeholders in the project cost (Gido & Clements, 2003).

2.4.4 Quality Management

The importance of quality management is quite noticeable in project management literature (Choi et al., 2009; Din et al., 2010). In the success of construction projects one of the critical factors is quality. Quality of construction projects linked with
proper quality management in all the phases of project life cycle (Memon, 2011). In
the project life cycle, design and construction are the two important phases of which
affect the quality outcome of construction projects significantly (Dahlia, 2010).
NEDO (National Economic Development Office), London survey found that
"design" and "poor workmanship in the construction process" combined to form
more than 90% of the total failure events (Rahman, 1996). The cost of the design
phase accounts for only about 3% to 10% of the project on average, most of the
research into and discussion of the quality of construction projects have focused on
the construction phase, and seldom on the design phase (Rahman, 2008). Quality
during the design phase has great impact on later expenditures (Memon, 2011).

In Malaysia, the application of the cost of quality concept in the construction
industry is a relatively new field of interest. Hence, the economics' sense of
improving quality not well understood within the players of the building construction
industry. It is no surprise therefore that some building contractors may avoid quality
improvement processes believing that these processes add only time and cost to the
process of construction. In the same time, less satisfactory performance in the
construction industry has led to the belief that construction projects cannot be
complete within budget and desired quality (Rahman, 1996). The findings of UK, the
BRE (Building Research Establishment) also found that, 50% of errors in buildings
had their origin in the design stage.

2.5 Issues of Construction Project Management

Projects defined by the need to complete a task on time, to budget, and with proper
technical performance/quality. A major criticism facing the Malaysian construction
industry is the growing rate of delays in project delivery. Time overrun and cost
overruns factor have contributed to the high cost of construction in many countries
for many years (Abdul Rahman et al., 2008). When projects delayed, contractor and
the project owner must plan ways to handle this unexpected delay. It causes
construction cost overrun. The research by Kaming et al. (1997) showed that, the
major factors influencing time delays are design changes, poor labour productivity,
inadequate planning, and resources shortage, while cost overruns are generally
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