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The Potential Benefits of Building Information Modelling (BIM) in Construction Industry

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Abstract. Construction industry known as complicated, risky and uncertain that certainly contribute to project delay, cost overrun, low product quality and others. Building Information Modelling (BIM) knows as a promising platform that can solve those problems. BIM has been developed at a rapid pace to cope with the increasing complexity and difficulty of project management. The construction players especially contractors still unclear about what BIM truly is, how and when to use it. The purpose of this paper is to explore the extent of which use of BIM producing potential benefits across construction project life phase. The exploration is done by collecting secondary data from 56 contractors (G7) across Klang Valley. The data of were analysed using descriptive analysis which are the frequency analysis, average mean and cross-tab analysis. Based on contractors Level of Development (LOD), most benefits can be obtained were from the Design Phase rather from Construction Phase and Facilities, Operations and Maintenance Phase.

1. Introduction

BIM has been developed at a rapid pace to catalyst on the increase in the aspect of complexity and the difficultness of project management. Despite that, the genuine information still makes the usage of BIM falling low of its capabilities [23]. The development of BIM adaption in Malaysia is considerably very little and stagnant. This is far behind if make comparison with developed countries for instance Hong Kong, Australia, Denmark, Finland, Singapore and Norway [18]. In addition, education and awareness are the third thrust of Malaysian BIM roadmap 2014-2020. Some criteria and conceptual of BIM adaption were reviewed and conclude in most study of BIM technology [4]. The number of studies that focus on the BIM awareness among Malaysian contractors are still low [8].

At present, success level and the BIM progression are still not in a satisfying level. BIM is not fully entrenched when it comes to construction industry [5]. BIM consist of major advancement especially in technical and design aspects. Despite of that, the implementation of BIM yet still not being fully utilized by construction industry users [12]. Apart from that, BIM is lacking of widespread uptake and it is linking to the challenges and risks that are potential impending its effectiveness [6]. The interacting complex system in BIM for instance building, services machine floor layout, all these multiple layers requiring modelling to be done in careful manner [13]. BIM adaption among Malaysian construction player are significantly low because of insufficient knowledge on BIM and mostly they do not know



how, when and what to start [25]. Hence, it necessary to study the current implementation of BIM and together with determining the potential benefits to increase BIM awareness among contractors.

The construction industry players that in contacts with the project of 100 million sum and above are required to obtain a minimum score of 40% of stage 2 BIM maturity by 2020 [11]. In the report produced by CIDB at 2016 had justify that the willingness of construction industry to change for BIM only at 17% adoption which is extremely low. The previous work minister Datuk Seri Fadillah Yusof urged that BIM adoption in the country relatively lower only at 17%. It is very high difference as compared to other developed country such as United Kingdom, Singapore and United States which at 54%, 65% and 71% respectively [10].

There is an initiative to develop technology by the construction experts in a way to serve the demands in construction projects now to BIM technology [2]. Thus, it is compulsory to follow up to date technology and it is the moment we need to change the way of construction in Malaysia that has come. Nevertheless, the implementation of BIM is still limited and processing slowly [1].

The business of construction development made item orientated building item demonstrating displaying since early 90's. A few market divisions for example the structural steel used the parametric 3D modelling. These days, BIM apparatuses has turned out to be promptly accessible in the development business. It has turned into the reward of development industry's devotion to BIM for as long as 20 years [26]. What's more, development industry had meet to the degree of to acknowledge and mindful of the genuine advantages of mechanical headway. The hole in the work profitability and effectiveness can be cure with the assistance of Building Information Modeling idea. Consequently, it is the need to consider more on BIM and it tools to decide the best possible benefits and misfortunes it has toward the construction management [15].

2. Literature Review

The construction sector could be one crucial and proactive sector when it comes to Malaysia economy. Asian nation had been noticed that as a developed nation, the crucial function of the construction industry not just the aspects of economics process however additionally in enhancing the standard of life and expectations for everyday comforts of Malaysian people [3]. In the course of the most recent twenty years it's been contributing between 3 to 5 % of the blend economy GDP. The improvement blast in Asian country started in mid Nineties, basically once the launch of Vision 2020. Nowadays Malaysian construction industry keeps on developing altogether inside the local moreover as worldwide market [22].

Base on its size, the business of construction industry might be a mammoth customer of every item and administrations [7]. For sample, the construction industry ingest an essential extent of Malaysia's producing sector, and additionally fundamental amounts of basic metals, ceramic, cements and distinctive building materials. The improvement of construction section go about as an outsized customer of higher esteem included hardware together with machinery also. Separated of been as the purchaser of made products, the construction business go about as a key shopper of a scope of administrations. Every last bit of it incorporates the learning driven consultancy and designing, other than go about as a wide base of money related administrations [10].

There are three major lifecycle phase in construction projects that has been induced by construction industry [24]. Design (D), Construction (C) and Operation (O) are the three major focus area. Somehow, there are more division in project phase. The division are namely; Feasibility (F), Program (P), Conceptual Design (CD), Detail Design (DD), Construction Planning (CP), Construction (C) and Operation (O) [14]. It is included that, Tendering and adjudication is one among the project lifecycle which coming after Detail Design and before Construction.

The definition given by above authors nonetheless, give off an impression of being conventional to incorporate any computerized innovation and some specialist examined it a bit much as long as it could add to frame office data. Some researcher underlined that, BIM go about as building simulation that gives am vastly improved procedure of correspondence toward all construction participants at different phase of the building life cycle [17]. Building Information Model allude to the spread sheet of

exceptional information drawing in the use of alphanumeric information to reenact a genuine business process in the building life cycle [14]. Not just that, it additionally includes the multifaceted nature and an interrelationship of association.

BIM development are categorized in five main stages which are called Level of Development (LOD) 100, 200, 300, 400 and 500. These LOD referring to the determination of project phase from early design process towards the construction process ended. Basically, LOD 100-200 focus on the traditional process involving 2D approach and for LOD 400 and LOD 500 are the exact BIM process. The LOD known as the phases that Model Progression Specification had been establish by BIM application and information input [20]. The application of each LOD divided into the pre-design, schematic design, construction design, construction documentations, fabrication and as built.

In light of a review contemplated, BIM selection level had been filled in as basic standard for the progress inside development industry [11]. The Malaysian development industry has been perceived as critical division that drives the economy of the nation [4]. In any case, regardless of being one of critical part, this industry perceive as among the business with most minimal profitability level. In this manner, several benefits of BIM application shall be listed with the goal that the construction players know about it.

The presentation of BIM benefits, will improve the design to be which can control the task cost life cycle and the project procedure too [21]. The potential benefits are can be sorted in a wide range of perspectives. The benefits can be classified in five viewpoints which are: Design aspects, Scheduling perspectives, Budget viewpoint, Communication viewpoints, and Documentation perspectives [19]. In addition, a research underlined that, six fundamental concern on the benefits of BIM adaption mainly due to; project client, system of innovation, project speed, cost vs time, competition and efficiency [16].

3. Research Methodology

To identify the level of BIM implementation and to perceived BIM benefits during the implementation, a quantity approach was used. Quantity approach provides comprehensive finding on the benefits of BIM from various perspectives [27]. The method approach includes a questionnaire survey among others which enables the generalizability of the results.

The set of questionnaire survey derived based on the collection of previous research. The questionnaire contains of 56 respondents demonstrating the potential benefits and being measured in the means of Likert Scale, with the score of one to five signifying 'strongly disagree' to 'strongly agree' respectively. BIM benefits section was derived as the benefits or value that respondent receive during each project life cycles. The potential benefits is divided into three project phase as in the questionnaire section where the first 24 variables are in the Design Phase, the following 19 variables in the Construction Phase and the last 13 variable in the Facilities, Operations and Maintenance Phase

Questionnaire was randomly distributed to 220 G7 contractors in Klang Valley. Klang Valley is an area in Malaysia which is centered in Kuala Lumpur and includes adjoining cities and towns in the state of Selangor. The limit of the area of geographical are mainly because of the time constraint and the accessibility of the researcher to carry the survey in Klang valley area. These set of questionnaires were hand out by the process of drop-and-collect technique and web survey to all selected area. G7 contractor are chosen because they are more experienced in the construction industry in Malaysia. The respondent contractors will be chosen based on types of projects being done and the contractor's profile.

The data were quantitatively analysed by using the Statistical Package for Social Science (SPSS). Descriptive analysis such as average mean and cross tab analysis were used in order to achieve the research objectives.

4. Results and Discussions

A total of 220 sets questionnaire were distributed to G7 contractor companies in Klang Valley. The questionnaire forms were distributed by hand and via online survey tool – Survey Face. A total of 56 questionnaires were collected, Table 1 summarized the socio – demographic of the respondents. Analysis shows that the male dominant the response rate which at 43 whereas the female respondent at

13 only with the percentage rate for male and female are 76.80 % and 23.30 % respectively. The majority of the respondent are from the Drafter or Designer position which is at 17 respondents (30.4%) from total respondents. Next, Site Engineer having 21.4% and the number of respondents is 12. There 11 respondents having current job that is not mentioning in the categorization. They are currently working as BIM modeler and Planning Engineer.

Table 1: Socio – Respondents Demographic

Description		No	%
Gender	Male	43	76.80
	Female	13	23.30
Position	Project Manager	5	8.90
	BIM Manager	3	5.40
	Construction Manager	1	1.80
	Managing Director	4	7.10
	Site Engineer	12	21.40
	Quantity Surveyor	3	5.40
	Drafter / Designer	17	30.40
	Others	11	19.60
Highest Academic Qualification	SPM	1	1.80
	Diploma	4	7.10
	Bachelor's Degree	44	78.60
	Master's Degree	5	8.90
	Others	2	3.60
Years of Experiences in Construction Industry	Less than 1 year	6	10.70
	1 – 5 years	31	55.40
	6 – 10 years	14	25.00
	11 – 15 years	5	8.90
	16 – 20 years	0	0.00
	More than 21 years	0	0.00

The age of the respondents are divided into seven categories which are the interval of 18-25 years old, 26-30 years old, 31-35 years old, 36-40 years old, 41-45 years old, 46-50 years old and lastly 51 years old and above. The response rate are only coming from 18-25 years old, 26-30 years old, 31-35 years old, and 36-40 years old. More than half of the respondents (51.80%) are in the age 26-30 years old which is 29 numbers of respondent. There is a fair of amount for respondents in between 18-25 years old and 31-35 years old which are 12 and 11 respectively. The remaining four numbers of respondents at the age of between 36-40 years old.

Academic qualification of the respondents are important factor that need to be consider in this research by taking in considering their expertise, knowledge, thinking and understanding. Bachelor's degree has domain at 44 numbers of respondents out of 56. Five person having master degree and it seems like SPM on have one number of frequency. The data in table above showed that most of the respondents are in the construction industry in the range between 1-5 years at 31 numbers of frequency and dominant up to 55.4% of overall. Coming next, half of it conquer by the range of age in between 6-10 years which at 14 numbers of respondents.

Although the contractors were fully aware of BIM, and its application, the extent of its usage is not so much on the BIM features in the scope of level of development (LOD). Table 2 shows most of the contractors are using the BIM features up to LOD 3 which is at 37.4%. This indicates, the contractors

have use the capability of estimating construction, monitoring the clash detections and visualizations. Somehow, the usage of LOD 5 adaptability is only at 3.3%. This showed that the facility management system cannot fully adapt to the building models. This will affect the operation and maintenance of building systems.

Table 2: Extent of BIM Usage

		Responses	
		N	Percent
LOD	Level of Development (LOD) 1	16	13.0%
Level	Level of Development (LOD) 2	13	10.6%
	Level of Development (LOD) 3	46	37.4%
	Level of Development (LOD) 4	39	31.7%
	Level of Development (LOD) 5	5	4.06%
	None	4	3.3%
Total		123	100.0%

Table 3 showed the results based on the survey answer by contractors by listing the possible potentials of BIM in the design phase. Results showed that the average mean for all 24 variables in this question are 4.32, indicate that the contractors mostly agreed with the benefits that the respondents received at design phase stages. The average index of this findings is in between 3.80 ($\sigma = .961$) to 4.59 ($\sigma = .596$). BIM detected potential clashes in the early design stage before construction process starts is the highest mean with the average mean is 4.59 ($\sigma = 0.596$). Clash avoidance is actually the key part of the design and construction process. Most of the time, during the design process, every BIM modules or users shall assess design decision and clashes to see if the problem can be resolve internally by the contractor themselves. BIM also will benefits contractors in support decision making regarding the design ($M= 4.54$, $\sigma =0.503$). In actual BIM process, the viability of the end products can be detected earlier with the help of BIM. Hence, any clash can be well proven by BIM implementation. Decision making is compulsory throughout the design stage of any projects. Thus, with BIM the decision can help to solve all design related problem. In addition, BIM benefits in clearing the concepts and project conceptualization easier ($M= 4.50$, $\sigma =0.539$). It can be generalize that with all the design making with BIM, the models become an ultimate concept tools to convey the project scope, step, outcomes and requirement. Among contractors, there is quite lacking in project conceptuality, they are more focus on constructability because they depends more on the consultants. This is the reason this potentials variable becoming the top three potential benefits.

However, respondents feels that BIM will not be able to reduce the knowledge gap of senior and junior staff ($M= 3.80$, $\sigma =0.961$). Mostly, in contractors' firm, they were reluctant to appoint the personnel related to BIM. There were still many organization does not have a BIM manager. Thus, there is not much gap identification of senior and junior staff. Next with BIM, it is not necessary improving the organization itself ($M= 3.93$, $\sigma =0.892$). All respondents agreed that it contributes to organization improvement. Yet, the improvement of the organization can be get through many medium not only the implementation of BIM. Respondents were as well less agree of the practicing current innovation as the main potential benefits ($M= 4.00$, $\sigma =0.972$). Digital technology such as BIM is the key to improve construction industry productivity. Somehow, contractors does not quite agreed with this variable as it seems that BIM has been developed earlier and the main concern is not be fully implemented.

Table 3: Benefits of BIM at Design Phase

Benefits of BIM	Mean	Std. Deviation
Concepts becomes clearer and project conceptualization easier	4.50	.539
Earlier and more accurate visualizations of a design to the owner	4.50	.539
Support decision making regarding the design	4.54	.503
Improve feasibility studies	4.29	.624
Improve simulations and coordination	4.30	.658
Improve design quality	4.43	.628
Design and installation services coordination improved	4.41	.565
Building proposal capability analysis increase	4.32	.716
Improved lean in design	4.16	.708
Improve design effectiveness	4.45	.570
Save design time and cost	4.39	.731
Improve mistake identification thus reducing conflict errors	4.48	.572
Utilize the coordination resolution in pre-construction	4.36	.672
Ease communication	4.12	.875
Organization improvement	3.93	.892
Practicing current innovation	4.00	.972
Reducing the knowledge gap of senior and junior staff	3.80	.961
Improve collaboration between construction players	4.18	.765
Enhance and improve planning process	4.43	.657
Enhance accuracy of existing documentation	4.41	.682
Risk reduction	4.27	.726
Simultaneous access	4.34	.721
Increase attention to the selection of the components of construction at early stages	4.41	.708
BIM detected potential clashes in the early design stage before construction process starts	4.59	.596

Table 4 below shows the benefits of BIM in construction phase. Majority of the respondents agreed BIM benefits in construction phase is clash detections ($M= 4.25$, $\sigma=0.640$). Respondents agreed that BIM helps to detect clash in construction phase due to the fact that with all of the building design completed on a capture and alteration of existing reality, the model will be the ultimate references to the ongoing particulars in a project. Hence, with the creating of design completed with information, clash can be detected earlier, and contractors able to reduce time, cost and improve quality. Respondents also agreed that constructability issues still arising during filed operations and once in the project environment, contractors can still improve constructability benefits with BIM implementation. With BIM, the many potential issues can be resolved by the 3D modelling ($M= 4.41$, $\sigma =0.626$). Implementation of BIM in construction phase will be able to reduce error, rework and waste for better sustainability for construction ($M= 4.41$, $\sigma =0.626$). With the availability of shared model in BIM, there is less rework need and duplicating drawings for the different requirement of a buildings. Since it is connected to the database, during construction the sustainability of construction will be enhance by less error and waste.

However, respondents feels that BIM will least help in the improvement of communication among stakeholders ($M= 4.41$, $\sigma =0.626$). When having the better handling process in clash detection and coordination, it helps in handling the keeping of sub-contractors work to be predictable. Hence, the communication will be improvised. Somehow, the reason most of contractor less agreed with the points is that, not all sub-contractors are of BIM implementation, and base more on the technical experienced technical point of view on site rather that follow up to the proposed design by BIM.

Table 4: Benefits of BIM in Construction Phase

Benefits of BIM	Mean	Std. Deviation
The improvement in understanding the sequence of construction activities and duration	4.36	.616
The improvement in visualization of construction details	4.27	.618
The improvement in synchronization of design and construction planning	4.34	.640
The improvement in constructability	4.41	.626
The improvement in risk identification and the suitability of risk management to made	4.13	.788
The improvement of safety features	4.14	.724
The improvement of quality and efficiency in construction management	4.20	.796
The improvement of project quality and BIM digital data quality gain	4.20	.796
The enhancement of contractors ability to make informed decisions, by estimation, coordination and scheduling the construction process	4.32	.636
The enhancement of productivity through time and cost saving	4.34	.640
The accuracy of scheduling	4.16	.757
Error reducer, rework and waste for better sustainability for construction	4.41	.565
The improvement of communication among stakeholders	4.13	.740
Quick reaction to design changes	4.29	.731
Optimizing the clients experienced and satisfaction	4.30	.685
The increase in workforce effectiveness	4.23	.763
Dispute resolution	4.27	.674
Reducing whole project's life cycle cost	4.32	.690
Clash Detection	4.54	.602

Table 5 showed the findings of BIM in the facilities, operations and maintenance phase. BIM is very broad in terms of the process creating and managing digital information of a project. It creates available concurrent information on the use or the performance of the building. Contractors strongly agreed that the information on a building life cycle can be share more easily through the BIM as a medium ($M= 4.25$, $\sigma =0.640$). Next, BIM will be able to reduce the risk of losing project information ($M= 4.11$, $\sigma =0.731$). BIM as digital recorder of project coordination able to accelerates the adaption of standard building prototypes. Thus, the BIM provides the physical information about the building such as furniture, types of finishing and necessary equipment. The risk of losing the project information can be reduce through this means when it comes to management phase.

Somehow, respondents feels that BIM will least help in increasing the staff personal efficiency ($M= 2.82$, $\sigma =0.596$). This variables in connected to design phase by including the staff in design process, the construction team will be more capable of making decision accurately reflect to the design intent. Contractors may not aware of this potential benefits. In addition, Most of the contractors do not agreed to BIM as enabling review of maintenance history ($M= 3.00$, $\sigma =0.640$) as the BIM conducted is currently below LOD 500. Facility maintenance management (FMM) is not much being conducted by respondents. Hence, most of them were having neutral answer on this variable. BIM helps in FMM by usage of geometry 3D oriented data to support the maintenance services which including the basic descriptions, parameter-related data together with records and reports of maintenance.

Table 5: Benefits of BIM in Facilities, Operations and Maintenance Phase

Benefits of BIM	Mean	Std. Deviation
The information on a building life cycle can be shared more easily	4.25	.640
The improvement in collaboration	4.11	.652
The enhancement of environmental sustainability	4.11	.652
The enhancement of the control of the whole life costs	4.09	.640
The improvement in emergency management	3.93	.657
Enhancing project closeout	3.95	.699
Reducing risk of losing project information	4.11	.731
Increasing the staff personal efficiency	3.82	.855
Keep track of built property	4.07	.828
Manage the property proactively	4.02	.556
Enable schedule maintenance	3.98	.674
Enable review of maintenance history	3.00	.745
Assist in controlling the subcontractors	3.91	.815

Table 6: Benefits in each LOD Level

LOD Level		Benefits in Design Phase	Benefits in Construction Phase	Benefits in in Facilities, Operations And Maintenance Phase
LOD 200	Mean	4.4583	4.5789	4.8462
	Std. Deviation	.	.	.
LOD 300	Mean	4.2652	4.3828	4.0559
	Std. Deviation	.51142	.43087	.46928
LOD 400	Mean	4.4278	4.3912	4.0744
	Std. Deviation	.35422	.42143	.49088
LOD 500	Mean	4.1574	3.9825	3.8632
	Std. Deviation	.47268	.60182	.55971

For the perceived benefits for each LOD (Table 6), respondents who implement the LOD 200 contributes highest means on the potential benefits given in the Facilities, Operations and Maintenance Phase with the mean of 4.8462. However, the validity of the information cannot be guarantee due to the fact that only one contractor's organization tied to LOD 200. Next, for LOD 300 the highest mean goes to the potential benefits of BIM in Construction Phase with the means of 4.3828 and the standard deviation of 0.43087. This information is gained by eleven number of respondent who established BIM at LOD 300. There are total of 30 numbers of respondents applied BIM LOD 400. With the means of 4.4278 and the standard deviation of 0.35422, most contractors agreed that potential benefits of BIM can be seen in Design Phase. Last but not least, total organization which applied BIM up to LOD 500 is not much; nine numbers. The highest mean goes to Design Phase with the mean of 4.1574 and the standard deviation of 0.47268.

5. Conclusions

BIM is definitely bring its own potential used at all stages of the project life-cycle, especially towards all the stage mentioned above. These all good to be practiced widely by the contractors to cartelist the project requirements. Apart from that, the potential has been applied in by the design team to analyze and design together with develop the particular projects. Next, it leads to contractors by process of managing the construction of the project and during the facilities, operations and maintenance Phase managing by the facility manager.

Given the findings of the result, it had shown that there has not been a greater take up on BIM when it comes to construction projects. And of course, there are many barriers identified thus experts should know about these difficulties so as to guarantee the potential benefits of BIM in development industry been connected and figured it out.

There is a need for every means to enhance the BIM adoption level in Malaysia. It is necessary to have marketing and BIM selling which supported by rigorous cost or benefits analysis. Although the initial cost of BIM is quite higher than CAD platform, however over the long haul the expanded profitability conceivably accomplished by BIM. Perhaps, based on this dissertation it is proven that it is more difficult to achieve the BIM objectives when it comes to people perspectives. Hence, it is a need for senior management in contractors firm to infuse in BIM education and training.

All in all, contractors needed to see that potential benefits of BIM can lead in bigger context. BIM definitely has its very own potential use at all phase in construction industry; benefits of BIM in Design Phase, benefits of BIM in Construction Stage and benefits of BIM in Facilities, Operations and Maintenance Phase. Through the survey made, contractors have been exposed with list of potential benefits. It can conclude that, most of respondents agreed that BIM provides many benefits. In order to drive and enhance the adoption level of BIM in construction industry, contractors needed to be well expose of the benefits of BIM can lead to. Transformation towards the new technology; BIM require strategic plan. In order to achieve BIM fully adoption, enforcement by government is needed. At early stage of implementation, the enforcement by government towards BIM as a driver for construction project is necessary.

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