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Assessing Building Information Modelling Effectiveness On The Project Performances

Muneera Esa*, Praveena Munianday

School of Housing, Building and Planning, Universiti Sains Malaysia, 11800,Penang, Malaysia.

E-mail addresses:
muneera_esa@usm.my (Muneera Esa)*
praveenamuniandy20@gmail.com (Praveena Munianday)
**Corresponding author*

Abstract— Building Information Modeling (BIM) implementation is regarded as an intimidating reality because most construction stakeholders are unfamiliar with the technology's potential benefits. Validation and application of BIM benefits could significantly improve project performance. The purpose of this research is to examine the actual impact of BIM technology as a tool for improving project performance and to investigate the actual benefits that have been achieved from adopting BIM applications in construction projects. To achieve the research objectives, the researcher used the qualitative approach to reach conclusions. Data was collected through a case study method since there is a need to investigate multiple BIM projects in detail and obtain further clarifications on project performance based. Three BIM projects were shortlisted out of 32 BIM projects approximately in Malaysia. Semi-structured interviews with BIM practitioners were conducted. The collected data were analyzed using the qualitative data analysis software NVivo. The analysis was classified into three groups mainly: time, cost, and quality. It was concluded that incorporating BIM applications in construction projects could improve project performance, particularly in terms of time restrictions. To be more specific, the detection of clashes under the time benefit is regarded as an extraordinary performance, among others. Furthermore, the study establishes that the local construction sector has yet to investigate quality aspects of BIM performance. These results provide ample evidence that BIM application has a substantial impact on construction project performance. When it comes to thriving in BIM-based construction projects, industry practitioners can use these proven project outcomes to establish strategic goals and priorities efforts more effectively. The findings of this study will provide users with a better understanding of the integration between BIM applications and construction project performance.

Keywords— Building Information Modelling (BIM), construction projects, project performance

I. Introduction

The construction sector has been reshaped with BIM technology into the framework of modern construction. Malaysian BIM perspective according to BIM Guide 2016 Awareness module 'A modelling technology and attributable set of processes for producing, communicating, analyzing and using digital information models across the whole life cycle of the construction project' [1]. BIM's wave has hit the Malaysian construction industry's shore for the past couple of years. Learning and assembling this vital information towards 2020 is important to both graduates and construction industry professionals [2]. According to the Malaysia BIM Report 2016 players in the construction industry that are plugged up in government deals worth more than 100 million by 2020 will be required to maintain a Stage 2 BIM development execution rate of at least 40 % [3]. In order to control the construction industry towards this target, evaluating the status of BIM adoption in Malaysia is essential to guarantee that the advancement of construction methodology can be utilized as an overarching framework for the execution plot. This is often one of the courtly strategies from the Government to assist and advance the potential as well as benefits of BIM within the construction industry.

The Malaysia BIM report 2016 hence incorporates a survey that measures the level of Building Information Modelling adoption and a basic standard for the move into BIM appropriation within the Malaysian construction industry. The breakthroughs where 84 percent of the reactions are willing to explore BIM's execution, although we have the industry's wide awareness and willingness to change for BIM, the BIM adopters' rate (17 percent) is relatively low. And thereby, it determines Malaysia's considerably low BIM utilization rate underlines the importance of BIM spreading within the construction entity [3]. As a government-led push, starting 2018, public projects worth RM100 million and over is required to utilize the Building Information Modeling (BIM) formulated to organized BIM in PWD. The desire behind BIM usage in PWD is to improve the efficiency and proficiency in conveying and managing Governments' project. It is demonstrated that with BIM handle execution, efficiency can be improved through effective collaboration handle, expanded return of investment and dependable data to bolster the decision-making process.

Project performance can be upgraded through design process, the solid and exact fetched cost estimates, decreased monetary hazard, and decreased potential debates among construction players. In bringing together the progression in technology which emphasizes an enhanced performance construction environment alongside the Government's initiatives in actualizing BIM, to public projects sets a super amazing illustration of BIM adoption in Malaysia.

BIM uptake in Malaysia's construction industry is at an infancy stage [4]. Considering Malaysia's minimal take-up of BIM, there has been an expanding need to realize the significance of BIM application in construction projects. There is a drive to develop understanding on how the BIM adoption enhances the project performance based on the golden triangle of construction which are time, cost and quality aspects. Through some fact-finding sessions, it has been identified there are lack of studies that have been conducted by local researchers on actual BIM projects to identify the certainty performances of BIM application other than extraction from literature review and other BIM materials. Most conducted research on BIM is on the general BIM benefits, risks, issues, challenges etc.

II. Literature Review

A. Concept on Performance of Construction Project

Performance is a concept that is usually mixed up with productivity. Referring to Aki Pekuri [5], productivity is more related to the ratio among output and input, whereas performance is a broader concept that comprises every aspect of the industry's economic and administrative aspects. Performance can often be outlined like an umbrella concept for all the issues concerning the company's success and its projects. Correspondingly, Tangen [6] described that, however, both the terms efficiency and effectiveness are to some degree cross-functional with respect to performance, productivity, and profitability. The generic areas of performance that most company aims to enhance are cost, fast delivery, adaptability and reliability. This region relates to a company's capacity to compete and meet client desires hence supplying some insights into the company's overall performance. Performance should be evaluated from various angles as the result of many well-performed elements is elevated productivity.

Developing a measurement system that connects company goals to activities and provides appropriate business environment data highlights the correct regions for improvement. The prime aim of performance measurement is to meet the company goals and objectives in order to improve hence setting targets for improvement activity [5]. New dimensions of performance have been implemented, including environmental performance and quality performance. Alternative approaches to capturing project performance information were developed with the assistance of ICT, including automatic data collection with sensors, use of crowdsourcing, and information collection through a prevalent database where multiple users can enter information and set up a benchmarking database [7]. Productivity seemingly to be more tangible compared to performance. Remarking to, Aki Pekuri [5] performance tend to have more characteristic when it is referred to excellence of the project, it incorporates profitability and productivity as well but only among the other non-cost variables, such as quality, speed, conveyance and flexibility. This is one strong reason to hold up on performance rather than productivity since this paper is focused on the cost, time and quality aspects of Building Information Modelling (BIM).

Quality and time are still comprehensive and subjective to be categorized as tangible, but the cost is tangible, so performance would cover the three aspects impeccably. BIM offers the potential to address these challenges and improve construction industry performance [8].

1) Project Performance on Time Aspect

a) Design Review

Love [9] affirms that design changes and errors are the main issues that have always been their threat to construction projects which deliberately leads to time and cost expenditure. With respect to this issue, BIM seemed to be a savior in enhancing productivity in delivering the project. Design reviews aid by avoiding common construction errors like variation orders, miscommunication, and incoordination between team members hence reducing the need to do repetitive work. One significant benefit where BIM increases productivity and efficiency, assess time and cost associated with the design change. [10].

b) Speedy and Effective Operation

The Request for Information (RFI) is significantly low and on-site coordination issues considerably through BIM adoption. Reinforcing this statement, a survey carried by NBS [11] proved that approximate figure of 48% of building clients tend to enjoy benefits towards the overall project outcome. This could be due to the speedy and facilitated decision making advantage for design or on field complications [12]. Notably it allows add value options and information can be transferred in ease and reused at crucial times. Moreover, a majority see that BIM brings better document coordination, cost efficiencies and faster delivery. Clients and contractors will increasingly insist on BIM usage [11].

c) Scale down on Alteration Works on Design

The 3D visualization facility on BIM usage benefits the Quantity Surveyors when, it comes to preliminary cost estimating. It goes easy on quantifying the materials needed and, indeed, most of the time accurate as well. Moreover, the design intent of a building via both qualitative and quantitative, can be monitored at an earlier stage [12]. The alteration works will be diminished because the design changes will be updated automatically to the BIM model, perpetually reducing drawing omissions or glitches [12]. NBS [11] verified in its report that above the average of 80% of people are convinced that BIM's topmost duty on reducing alteration works is successful. Now, bringing down the human errors and repetitive work is possible thanks to BIM for concentrating on attitude and working methodology throughout the project's life span [9].

d) Significant Clash Detection Feature

Also, BIM tools allow teams to spot clashes that would sometimes go unreported until well into the construction phase once it is much more expensive to fix such errors. Getting it done the first time prevents the waste of a huge amount of effort, material, time, and money is the priority of BIM. Whereas the conventional method of 2D drawings changes made on one drawing is not automatically updated in another causing inconsistency, errors and omissions. This not only results in variation orders but causing on-site and legal disputes. BIM abolish these types of faulty issues and brought down the cost, on-site errors, legal disputes, and excellent project methods projects as a result [12]. In addition, one of the top seven BIM advantages that influence Malaysian companies to adopt BIM is the reduction of conflict design [10].

e) Teamwork Advantages

Cloud-based design strategies such as the BIM 360 Team and Revit Collaboration empower real-time collaboration across design stakeholders to deliver more comprehensive, accurate drawings to construction teams. BIM uses photo-realistic graphics, or convertible formats thereof, to transmit information. BIM offers enduring on-screen instruction, simulation, knowledge sharing, and value integration platforms. Hence this eliminates risks related to glitches, contradictions, and subjectivity. Project stakeholders, as project knowledge and communication are streamlined, are more able to incorporate and cooperate effectively. Project stakeholders are more likely to integrate and collaborate effectively when project information and communication are simplified [13]. Multidisciplinary reconciliation of teams permits the distinguishing proof and determination of issues ahead of time of construction. BIM has the competency to interfere with the 'shared frame' by

conducting specific power struggles within project stakeholders [14].

2) Project Performance on Cost Aspect

a) Fabrication and Construction Advantages

BIM facilitates the manufacturing process. The 3D traits from the model can be conveyed to the factories for the segment production is fully automated. Usage of the 4D BIM allows impersonating how the real building looks towards completion. Moreover, it reveals the potential refinement that can be investigated throughout the project life cycle [14]. Adding on to that, fabricator models can communicate with the design model effectively in order to present information for purchasing purposes [15]. Effective manufacturing of various offsite building components using the concept model as the core is crucial [16].

b) Accuracy in Taking off and Estimating

It could be any project, cost and time are key performance benchmark, other than quality. With BIM, it makes way for the Quantity Surveyors to produce detailed and accurate estimates. Some of the available features are, automate measurement, rapid estimating process compared to traditional method and upgraded capturing off quantities for better project information delivery. The fifth dimension (5D) is exclusively for QS for automated BQ production [18]. In addition, BIM can dissociate the exact quantities and ranges used to calculate costs in the design stage at any period. On the other hand, QS should understand and relate how the entire construction cost is made up of each building component or space via BIM as BIM allows the recognizable proof of the ratio of amounts to areas and costs. This improves QS's competence through a thorough understanding of the determinants obtained, which in turn results in a cost estimate with predominant accuracy and reliability [18]

3) Project Performance on Quality Aspect

a) Health and Safety

As of now, the construction industry has shifted positively towards improved efficiency by reducing in the cost and project completion duration in respect to safety management [19]. The Health and Safety Executive recognized BIM, and the progress is to build synergy effects between BIM and health and safety management. The importance of implementing this method for health and safety management is well appreciated. For example, according to Cousins [20] the use of 4D to rehearse the planned construction activities in a simulated environment may be a key to facilitating precise site safety planning as it offers a forum for detecting potential hazards and modalities for trying possible initiatives to minimize risks in the pre-construction phase of the project. [21]. BIM provides rich and formal instructions and justifications for automated quality inspection in order to improve safety management [22].

The ultimate objective of BIM-based safety management quality inspection is to reduce the rate of predictable hazards to humans and thus eradicate risk factors throughout buildings' life span. BIM-based quality control and safety management testing can rely not only on performance but also on modelling skills and strategies to interface applications. Skanska [23], reports that safety planning is facilitated when the production team can review the virtual building through 3D BIM model and determine hazards before it occurs and plan how to mitigate them.

The 3D BIM model in Figure 1 demonstrates the importance of ceiling heights and delivery routes in the workplace owing to height loaded trucks and objects, such as mechanical, electrical and plumbing components that can contact beams. Figure 1 also evidently depicts safety strategies through BIM implementation, the clash detection characteristic is one massive advantage shown in the figure. Works can indeed be effectively coordinated with the help of clash detection, while field problems can be resolved virtually before they occur [23].

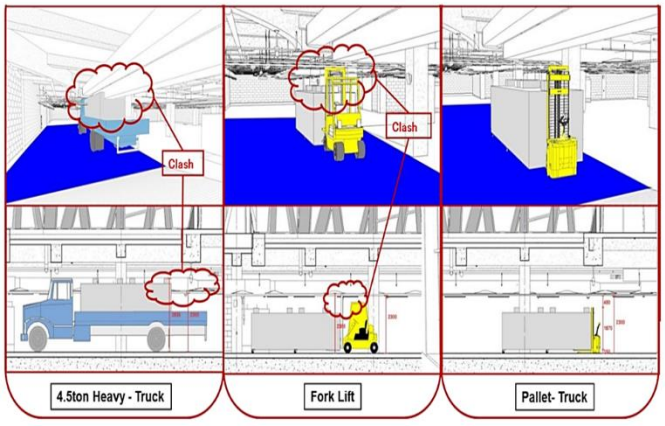

Fig 1. Safety inspection using collision simulations [22]

b) Functionality

Functionality is to be considered as one victory milestone that is made in the post-construction phase upon completion of the project and is ready to be used [24]. It would be meaningless, if the project undertaking fails to serve its original purpose. An example of a different view is the Sydney Opera House Australia. The building is supposed to be operated as a theatrical and opera house, but it serves more as a tourist spot rather than the original purpose. It is due to failure in accommodating the functionality [25]. The Opera House carries the fame and pride of the nation but, at the same time a failure from a project management practice since it undergone approximately 16 times over budget and four times the original contract period. Conversely, the Millennium Dome in London achieved the requirement by completing on time and budget as well as serving its purpose but, it was considered a failure to the British citizens due to failing in delivering the awe and glamour [25].

Functionality is, therefore, closely linked to the project participant's expectations and adequately measured by the degree of compliance with all technical performance requirements [24]. To accomplish fitness for objective purposes, both aspects of financial and technical should be considered. A clear cut defined specification on workmanship guidelines to contractors and other stakeholders by clients at the commencement of project execution is important for the project stakeholders to keep on track with the purpose of the building [26]. BIM facilitates this procedure by standardization advantages feature, which is empowering and systematizing interoperability among AEC BIM clients through the arrangement of standard models, including rich semantic and geometric data of building parts. Multidisciplinary reconciliation of groups permits the distinguishing proof and determination of issues ahead of time of development. This is essential in both, outlining new offices and incorporating new offices with existing ones. Early multidisciplinary reconciliation permits superfluous cost and time impacts by diminishing mistakes and demands for data also, consequently decreasing revamps [27].

c) Sustainability

In the context of sustainability, BIM ensures many feasible ways in which buildings can be planned, constructed, maintained, and decommissioned in a more sustainable manner [28]. Commonly, the beneficial effect of BIM implementation on the construction sector's sustainability is conveyed via the concept of sustainable construction plan [29].

Environmental sustainability is extensively minimized through BIM operation on energy, water consumption, used materials, waste management, carbon footprint that allows all kinds of building and project related information to be located, shared and processed. Whilst the principle of economic sustainability largely ensures economic viability with increased productivity and lower production waste. Economic sustainability encompasses earlier identification of anticipated conflicts, value engineering decisions, improvisational logistics, and specific ex-ante cost estimation across the lifecycle of the project [28].

Finally, social sustainability is the attempt at making a healthy and inhabitable community by gearing up tools to improve operation in such waste management points of view, indoor discussion of quality, noise pollution, safety at the construction site, to be accurate and troubling activities on government infrastructure. In addition, sustainability-related data that BIM has constantly accumulated and analyzed can be turned into a tool of social engagement by including tenants in setting common sustainability goals for their buildings, checking progress and praising achievements. This use of BIM does not contribute as it were to the "greening" of the built environment, it also enhances the interaction between tenants and strengthens social bonds [28].

III. Methodology

Considering the key usage of Qualitative Research, this research is carried out in this manner. The project performance needs to be explored with a precise group of which are the BIM adopters since BIM is a complex and involves technical issue which needs a detailed understanding on it. Through the BIM adopters' voices, it would be easier to empower other individuals like Clients to link the BIM project performances theories with an actual project. Only qualitative research is competent to achieve this objective.

1) Case Study Method

This research will be exercised through a case study method since there is a need to investigate multiple BIM projects into detail and obtain further clarifications

on project performance based. The type of the case study would be explanatory. Where there will be explanations and defining why things happen, exploring the cause-effect relationship. This research is an exclusive case study on BIM projects in Malaysia. This case study if intrigued on the key participants of the construction industry that have involved directly and indirectly to BIM projects in Malaysia. This group is incorporated of Architects, Consultants, BIM Consultants, members of Public Work Department (PWD) and as well as other functional parties to stimulate their views on the Building Information Modeling (BIM) interface to describe project performance issues in BIM projects in Malaysia.

2) Sampling Design

Upon further discussion with the PWD BIM Division personnel, it revealed that there are in total of 17 BIM projects held by them, where seven are completed, six under construction and four more still under tendering stage. The projects are inclusive of Pilot Projects and BIM Projects. Moreover, the PWD BIM Division personnel also affirms that there are less than 15 numbers of BIM projects in Malaysia apart from the Government ventures (private projects). Hence, it was identified that there are in total of 32 BIM projects approximately in Malaysia meet the criteria stated above.

The entire BIM projects consist of a variety of schools, hospitals, integrated developments, universities, government offices, residences etc. The thirty-two BIM projects were the entire samples, and three BIM projects were shortlisted from it.

The three BIM projects were selected based on the availability of the organization to provide sufficient information on the project, readiness to carry out the interview session, expertise available, terms and conditions of the BIM projects and some private, and confidential matters. The criteria on BIM project likewise mentioned in Table 1 are achieved as well.

TABLE 1: BIM PROJECT CRITERIA

No.	Project/ Organization Activities
1	Establishing BIM standard and common practice (standards, technical codes and object-oriented classification for Architect, C&S, M&E, QS, and FM.
2	Build a reference document aiming at providing a unified BIM standard/ methodology/ convention/ required level of details that can easily be easily adopted to suit different projects with reasonable modification
3	CAD to BIM migration along the construction value chain (Design, construction and FM). To standardize and formulate standard, guideline and procedure to the required level of development (LOD)
4	Promote the adoption of BIM throughout the construction supply chain in the project
5	Accreditation for certification of completed BIM project and BIM user (Architect, C&S, M&E, QS, and FM) by BIM certification and qualified body (to be appointed).
6	BIM implementation to entire project without restriction only on certain activities. Achieve at least Stage 1 of BIM, transition from 2D TO 3D.
7	Achievement of the BIM project performances (time, cost and quality) all three or any of it.

A. Techniques for Data Collection

Interviews are a suitable way of gathering factual data about the views, thoughts, and experiences of people. Confronted with an interpersonal role scenario in which an interviewer asks the respondent specific concerns to achieve responses linked to the research problem and objectives. The interviews were carried out in April 2019 and have been held in Wilayah Persekutuan, precisely Klang Valley area. Semi-structured interviews contain several planned questions, where there will be a room for the interviewer to modify on their arrangement of questions and phrases or terms to be used. In-depth interviews are treated less formal and structured where there may be wordings and questions which are predetermined [30]. The primary goal for this interview is to test participants ' ideas about the BIM performance and the challenges they encountered where they may be hesitant to share on first.

The In-Depth Interviews allow the interviewer to get extensive information on research areas [31], an interviewer will commonly have a series of questions prepared, and those are only used as a reference during the interview session, where interrogations from the prepared guidelines are often welcomed. That is where the interviewer can add extra unexpected questions that emerges regarding the area of study and omit questions that are irrelevant to participants.

B. Measurement of Construct

The questionnaire comprises two sections. The first section aims to gather information on the background of the respondents in the study. The second section measures the actual performance in terms of time, cost and quality of BIM projects in Malaysia construction industry.

IV. Data Collection

All three projects carried out BIM as a whole process and not only on key elements. It means that, across the whole execution of the project and throughout the entire operation, the consultants used BIM up to the handover procedures. The selection of these three BIM projects is primarily focused on their extensive BIM application in their projects.

A. Case Profile

As the basis for this case study, three BIM projects were preferred. All three projects carried out BIM as a whole process and not only on key elements. It means that, across the whole execution of the project and throughout the entire operation, the consultants used BIM up to the handover procedures. The selection of these three BIM projects is primarily focused on their extensive BIM application in their projects. Table II depicts the characteristics of the chosen three projects.

TABLE II: CASE BACKGROUND

Project ID	Type of Project		Procurement Approach	Size of Project	Location of Project
P1	Hospital Project		Design in-house	Malaysian Government Hospital	Perak
P2	Infrastructure (Railways)		Design & build, Project Delivery Partner (PDP)	The first line of the KVMRT	Sungai Buloh
P3	Residential & Retail Mall		Traditional	Integrated Project	Kuala Lumpur

The profile of the professionals participating in the in-depth interview is shown in Table III.

TABLE III: RESPONDENT PROFILE

Expert ID	Type of Firm	Position	Experience (Years)	BIM Exp (Years)	BIM projects Involved

R1	Government Department	Senior Assistant Director	12	7	4
R2	Government Department	Engineer (BIM Modeler)	7	4	3
R3	Contractor	Mechanical & Electrical Engineer	7	4	2
R4	Private Property Developer	Project Manager	32	4	3
R5	Private Property Developer	Architect	7	4	2
R6	Private Property Developer	Quantity Surveyor	30	3	3

A. Interview Results

1) Respondents Perspective on BIM projects performance in terms of time, cost and quality

Objective: To assess the performance of BIM projects in terms of time, cost and quality when implementing BIM application.

TABLE IV: RESPONDENTS PERSPECTIVE ON BIM PROJECTS PERFORMANCE IN TERMS OF TIME, COST AND QUALITY

	R1	R2	R3	R4	R5	R6
			Time	**Factor**		
Teamwork Advantages	✓	✓				
Significant Clash Detection	✓	✓	✓	✓	✓	✓
Scale Down on Alteration	✓	✓	✓	✓	✓	✓
Speedy & Effective Operation	✓	✓	✓	✓	✓	✓

Design Review	✓	✓				
			Cost	**Factor**		
Accuracy in Taking Off & Estimating			✓			
VO	✓	✓				
			Quality	**Factor**		
Sustainability					✓	

Table IV certainly summarizes the opinions of the participants and further illustrates the intensity of similar factors among the participants. The respondents were asked on the performance of their BIM projects in terms of time, cost and quality.

Generally, the respondents admitted that BIM projects better performance in terms of time, cost and quality if were to be compared with the conventional method. All respondents unanimously single-out time as the topmost clear performance outcome that they witness in their BIM projects. Specifically, by adopting BIM, all respondents agree that it allows Significant Clash detection, Scale down on Alteration, Speedy and Effective Operation. The clash detection key feature is one of the repetitively mentioned performance impacts by all the respondents. Respondent 3 clearly declared his opinion on this, and all the respondents have almost the similar comments like him:

"It helps to save the cost and for time yes it can save some time because we can solve the problem before the construction start, I mean before the actual construction starts because the clashes are detected beforehand. So, for BIM after implementing, for conventional right, we only find the problems after we build the buildings, so then we solve on the spot, but with BIM then we can solve before the construction starts. For an example, my current project I'm doing on ground floor and then one of our coordination has already reached level 1 soffit, so we can plan ahead instead of wasting time on structure till it is finished only we can find the problem".

Another benefit of BIM adoption is that it limits alteration, as exposed by R1 and R2.

"Alteration work is not a good sign of a successful project because, alteration works eventually increases the time taken to complete the project and increase the variation order issued to comprehend in making good of the unapproved work".

It will the best practice for every construction works to perform their job right at the very first time without having the need to do a U turn work. Sharing his experience on this issue R3 emphasized that:

"Especially the railway project, even small changes results into a huge amount of money. The cabling and M&E grounds for this type of project is very tedious".

Moreover, repetitive work eventually increases the project cost because when the work is being repetitive the previously constructed element must hacked which results in wastages and unnecessary spending likewise stressed by R5.

"Once we can reduce wastage, we can tackle the money issues and then in terms of construction, our target is to decrease hacking, coring work".

Not only it will limit alteration, adopting BIM also facilitates the decision making in a situation where there are amendments or design changes by client. One of the usual complaints on project delay would be the client taking up huge amount of time to make decision. As confessed by R2:

"In term of time, it would be even easier for us to make decision especially when the Client is clingy keeps changing the design, without BIM it takes huge amount of time to put the changes into paper. The contractors tend to face less loss in their profit due to this".

When compared with the conventional method, BIM adoption results speedy operation. Relying his/her experience in NSC project, R2 declared:

"For an example, when the NSC uses a conventional method, it uses much of his effort during construction but with BIM, only the design stage needs extra effort. Maybe

the design stage is lengthy, but the construction stage is much shorter because the coordination and visualization are too good. Through this, even the redo of works can be reduced".

Speedy operation maybe viewed from another angle where the long wait for RFI may be eliminated according to R6's P3 experience:

"One more, it fastens the RFI process, rather than the long wait for the reply. BIM allows the changes in drawing to be updated automatically like our current project data and information on the items are precise and up to date, then it shouldn't be a problem for us to do the measurement work during FA period".

Teamwork advantage and Design reviews are identified with equal benefits in the time performance benefits that respondents gained in BIM project. Teamwork is a vital element throughout a BIM. One of the clear requirements upon BIM adoption is to emphasize on collaborative working method rather than everyone performing their task at their own comfort zone. Respondent 1 evidently expresses on this:

"One strong point I would say is that adoption of BIM gives us a broader path to collaborate with our construction team, whether it's in house or outsourced. Whether our pilot project or BIM Project, transparency policy that we compromised among the construction members via BIM application".

On the other hand, this teamwork advantages are not limited to the consultants and the main contractor, hence the sub-contractor and nominated sub-contractor may as well be benefitted through this BIM adoption likewise stated by Respondent 2:

"The teamwork is our first gain from BIM Project which the M&E design only shows schematic, whereas the NSC have to prepare their own set of drawings. The M&E schematic model have to consider the possible clashes instead. BIM M&E design encompasses all scopes and possible discrepancies. Other than that, in term of time taken by NSC to make decision is faster".

Design review mostly due to the incoordination between team members hence reducing the needs to do a repetitive work. The lesser the design need to be reviewed also means the lesser the changes needed for the design. Respondent 1 feels that:

"The main motif of us using BIM is more towards 3D Coordination benefits. We also want to improve our work collaboration and reduce conflict during construction and redundant works"

Although not unanimously, respondents cited cost and quality as other performance benefits in BIM projects. In terms of cost performance, Variation order issues revealed by both Respondent 1 and 2 that:

"The contractors might have a positive side on cost reduction. For us, we only advice that BIM usage reduces the VO because of the fast decision making and able to reduce corrective works".

In addition, one respondent identified 'Accuracy in Taking Off and Estimating' as another performance in terms of cost in BIM project. The accuracy in taking off and estimating will affect the wastages. The accurate the taking off, the lesser the wastages. Respondent 3 through his experience on the P2 and previous projects agrees that:

"For cost, actually BIM fetches the benefit because the accurate costing derived from BIM, we can do order rotting and then we can know how many fittings that we need so we can cut the wastage on site".

In respects of quality performance, only the superficial view on sustainability is identified like the usage of IBS in BIM projects. As revealed by R5:

"Regarding quality we control by, producing 6 walls storing. For this project we just use some materials and method only to tackle the minimum requirement for IBS".

Figure 2 below further concludes the perspectives of the respondent on the BIM performance they experienced, while Figure 3 becoming even inclusive shows the perspectives of the respondent based on each factor in order to provide a better knowledge grasp and clarity of the objective.

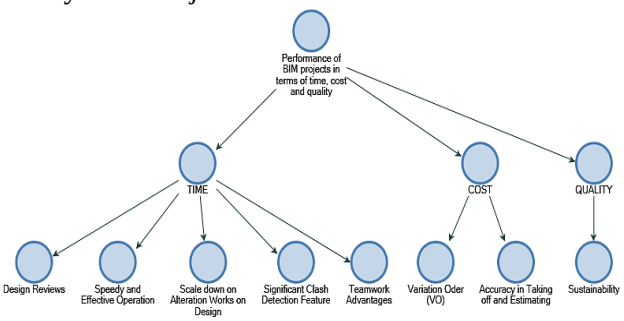

Fig 2. General summary of respondent's views on BIM performance

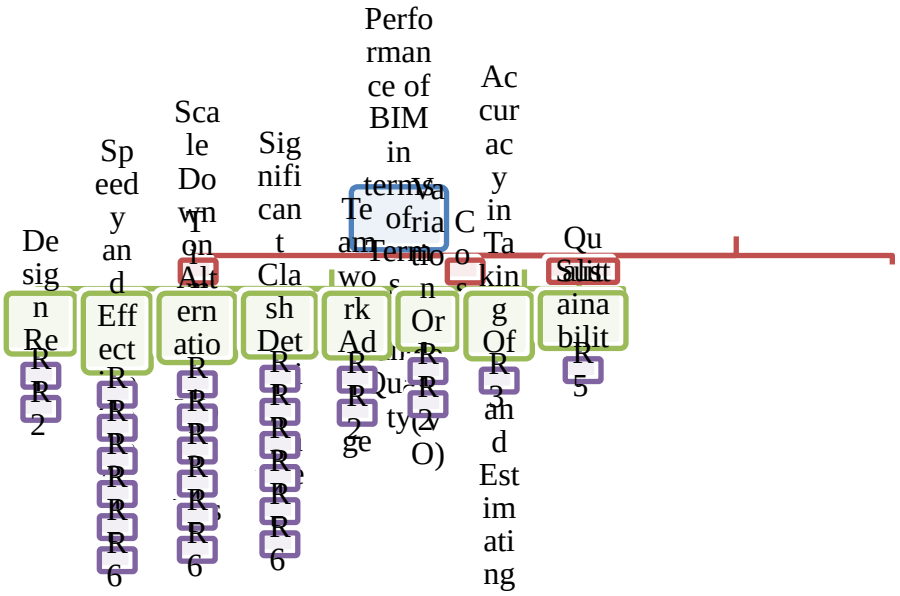

Fig 3. Specified summary of respondent's views on BIM performance

I. Conclusion

This paper aimed to evaluate the factors that influence the performance of BIM projects in terms of time, cost and quality when implementing BIM in construction project. Based on the research, time factors concluded to have the hugest impact to the BIM projects compared to cost and quality factors. To be more precise the clash detection under the time benefit deemed to be the outstanding performance. Minimal VO, as cost performance added advantage deemed to the key findings for this objective. Lastly, the Quality performances in BIM projects aren't encountered by majority of the respondents.

The outcome of the interview was analyzed, and the most valuable performance were the time factor among the cost and quality apparent BIM performances mentioned in Chapter 2. For instance, clash detection is the most desirable feature in BIM, which gives impact to time and cost factors. Thus, the research finding also can deduce that the local construction industry has yet to explore the quality aspects of BIM performance and that they are more concerned with time and cost issues. The key finding in this objective is the reduced number in VO issued which eventually gives impact to cost performance.

Lastly, the study enriches the existing understanding on BIM performance by identifying time factor as the most prudent advantage highlighted by all the respondents. New performance factors namely minimization in VO produces under the cost performance is a new finding.

Future studies should test the identified performance factors via quantitative research methodology to enhance our understanding on the subject. Other than that, it would also be valuable for a similar study to be conducted and validated in other developing countries since differences in aspects such as locality, culture, economic, political views and policies could result in different outcomes.

Acknowledgment

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