BIM: The setback OR solution to project cost issues in Malaysia construction industry?

P S E Ang¹, Y L Pung¹, K L Tsai¹, M NA Zulkaply¹, J S Tey², N B Kasim² M H Osman¹, M K Musa¹ and M A Abdul Rahman¹

¹ Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia
² Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia

Email: peniel@uthm.edu.my

Abstract. Malaysia is progressing into Industry Revolution (IR) 4.0 which emphasizes more onto digital, data and artificial intelligence where everything is expected to be automated. However, cost tends to be a major issue at the pioneer stage of embracing technology where Building Information Modelling (BIM) for example tends to be a cost tussle for the current construction industry. Yet, research has shown that BIM is arguably one of the technology platforms in combating the costing issue considering that BIM enables 3D model elements to link to cost and auto-generate quantities which potentially achieve cost-effective project. Due to the conflicting perspectives of how BIM affects project cost issues, it is imperative to investigate the cost-related issues in implementing BIM in the project and to determine how BIM in general positively influences the overall project cost. Qualitative research is adopted in this study. A semi-structured interview was conducted among four professionals who employs BIM in their project. They consist of the assistant manager, senior manager and chief executive officer. The data collected is analysed by utilising Matrix Table for better organisation. The scope of the study is in the Selangor state in which the local construction industry had applied BIM in their construction industry up to the 3D stage. The results showed that the BIM implementation cost is not too burdensome as it is only a one-time cost and does not vary throughout the project period. In addition, the BIM influence on the overall cost of the project is beneficial to the industry. It improves workflow and cost management. In conclusion, BIM is beneficial to the construction industry in the long term. It is important to resolve the cost-related issues for implement BIM and hence, encourage the usage of BIM, especially in the IR 4.0 ecosystem.

1. Introduction

Delay and cost overrun are the most common problems in the construction industry in both developed and developing countries [1]. Construction projects are frequently delayed due to many factors such as inefficiency of cost performance which can be led by poor data management on cost, cost overrun, and lack of management policy on control practice. Thus, Building Information Modelling (BIM) implementation is essential in managing the cost aspect of construction project in Malaysia.

BIM is a solution to eliminate those cost issues such as cost overrun and also delay. Unlike conventional methods such as Bills of Quantity and architectural drawing, it uses software that integrates with BIM to manage project flow. With the usage of BIM, data is more secure as it can be uploaded to cloud and also updated directly by users.
Current BIM implementation in Malaysia is only limited to 3D modelling without applying 5D BIM system to construction projects. With 5D BIM implementation, it is estimated that cost issue can be resolved and also eliminate any unnecessary cost that could have happen throughout the projects which may lead to over-budget.

BIM adoption rate is currently at 17% in Malaysia where the stage is still in modelling which is 3D [2]. However, other countries such as United States, the usage of BIM is at 70% or more. United States and Korea which has implemented BIM in a broad range, achieved an economy rank at 1st place and 11th place respectively whereas Malaysia economy state was ranked at 38th as in 23rd March 2018 according to the International Monetary Fund World Economic Outlook [3]. Therefore, this paper resolves to investigate the cost-related issues in implementing BIM in construction project and to determine the positive influence of BIM on overall cost project.

2. Literature review
This section encompasses the review on the cost performance issues in the construction industry followed by the introduction of Building Information Modelling, cost performance of BIM project in other countries and impact of BIM implementation on project cost performance in Malaysia.

2.1. Cost performance issues in construction industry
Cost performance can be a major setback or a success in a construction project. Cost management in construction industry is less effective compared to time management [4]. According to [5], there is too much optimism in estimating cost and determining of duration of project with expectation of smooth flow of work. In every project, project manager needs to foresee the unexpected problems occur that may cause a major setback instead of being optimistic for smoother project workflow.

Only 16% of projects conducted has achieved the expected time and maintain project within budget with the exact right specification. It is also known that cost overrun issue is much frequent occur than the extension time issue which shows the cost aspect is inefficiently managed in a construction project [6]. The factors of cost overrun are design changes, inadequate planning, unpredictable weather condition and fluctuation of building materials cost [6]. Design changes can occur due to client changes that may eventually lead to additional cost for adjustment. However, design changes may also be linked to inadequate planning where finalize design has a mistake where it is overlooked, causing mistakes and delay works. Therefore, with BIM implementation, it can resolve the cost performance issue effectively.

2.2. Building information modelling (BIM)
BIM is the process of managing information throughout the life cycle of building from conception to demolition. The integration in project flow and delivery is facilitated by collaborating the backbone of BIM, the semantically rich shared 3D digital building models [7].

BIM has an extension of “nD” modelling which incorporates a different dimension of design information required and generated throughout the project lifecycle [8]. These dimensions are 3D (object model), 4D (time), 5D (cost), 6D (operation), 7D (sustainability) and even 8D (safety). For instance, 5D modelling is integrating “cost” dimension into the building model to enable cost budget and financial generation of the model against time. This BIM aspect could be essential to the work of the construction profession especially Quantity Surveyor where costing for materials take-off such as Bill of Quantity is determined by them [9].

2.3. Cost performance of BIM projects in other countries
In other countries, BIM implementation has been beyond 3D where 4D and even 5D implementation has already taken place. Therefore, the performance of that implementation will be reviewed to see the effectiveness of the system.

The first BIM project that will be reviewed is Aquarium Hilton Garden Inn project which located in Atlanta, Georgia [10]. This project consists of retail shops, mixed-used hotel with a parking deck, had a contract value worth 46,000,000 dollars. This project applied BIM for design coordination and clash detection (BIM 3D) and determine work sequence which is covered by BIM 4D. BIM implementation
cost is only 0.2% of the total cost of project which is equivalent to 90,000 dollars where 40,000 dollars is paid by the client [10]. The project has cost benefits from clash detection analysis as 55 clashes were detected within the pre-construction stage which in turn saves about 124,500 dollars. In the end, after further analysis through visualisation on modelling, the unnecessary additional cost was avoided and have a total cost-benefit more than 200,000 dollars on the project. Cost performance summary can be observed in Table 1.

Table 1. Cost Performance Summary of Aquarium Hilton Garden Inn Project [10].

| Collision phase     | Collision | Estimated cost avoidance | Estimated crew hours |
|---------------------|-----------|--------------------------|----------------------|
| 100% design conflicts | 55        | $124,500                 | n/a                  |
| Construction (MEP collisions) |          |                          |                      |
| Basement            | 41        | $21,211                  | 50 hrs               |
| Level 1             | 51        | $34,714                  | 79 hrs               |
| Level 2             | 49        | $23,250                  | 57 hrs               |
| Level 3             | 72        | $40,187                  | 86 hrs               |
| Level 4             | 28        | $35,276                  | 68 hrs               |
| Level 5             | 42        | $43,351                  | 88 hrs               |
| Level 6             | 70        | $57,735                  | 112 hrs              |
| Level 7             | 83        | $78,898                  | 162 hrs              |
| Level 8             | 29        | $37,397                  | 74 hrs               |
| Level 9             | 30        | $37,397                  | 74 hrs               |
| Level 10            | 31        | $33,546                  | 67 hrs               |
| Level 11            | 30        | $45,144                  | 75 hrs               |
| Level 12            | 28        | $36,589                  | 72 hrs               |
| Level 13            | 34        | $38,557                  | 77 hrs               |
| Level 14            | 1         | $484                     | 1 hrs                |
| Level 15            | 1         | $484                     | 1 hrs                |
|                      | 590       | $564,220                 | 1143 hrs             |
| 20% MEP material value |          | $112,844                 |                      |
| Subtotal cost avoidance |          | $801,565                 |                      |
| Deduct 75% assumed resolved via conventional method |          | ($601,173) |                      |
| Net adjusted cost avoidance |      | $200,392                 |                      |

Another project that implements 5D BIM is Ara Institute of Canterbury in New Zealand with a budget of 34 million dollars. 5D BIM is managed on this project by its quantity surveyor which is AECOM and Hawkins Construction as the main contractor. With 5D BIM, enabled AECOM to use intelligent data to provide Ara with fast and accurate quantities and costings [11]. According to AECOM, the reduction of cost planning time was reduced to 20 hours compared to two weeks and it enables the company to focus on obtaining specialist market cost. Besides that, quantity surveyor of the project was able to inform client and project managers on the impact of cost changes and options.

Based on the BIM implemented projects above, it can be clearly seen that through the implementation of BIM, it helps the project to complete ahead of time and save cost.

2.4. Impact of BIM implementation on project cost performance in Malaysia

BIM was introduced to Malaysia in the year 2009 but the adoption rate is still low [12]. Despite the numerous benefits that can provide by the BIM, yet, the usage of BIM in Malaysia is still limited. In Malaysia, the usage of IBS is about 15% - 20% of projects with 1700 buildings in the year of 2015.
[13]. There are two examples of buildings that were constructed with BIM and have proven the benefits of implementation of BIM could help the project cost and schedule.

The first project is the Healthcare Centre Type 5 in Sri Jaya, Maran Pahang. The project used design and build method [14]. Roles of BIM in these projects is to make site modelling, visualization, design review, clash analysis, 4D schedule simulation and record modelling.

Another project is the National Cancer Institution located in Putrajaya. The purpose of this Institution is to act as the first cancer institute for comprehensive care, treatment and referrals. The total area for the site is 4.31 hectare with a contract value of RM 690,000,000 [14]. The BIM tools used were Autodesk Revit for architectural, structure and mechanical and electric for 4D modelling. Another tool which was employed is Naviswork. As a result, the project was completed two weeks ahead of schedule. With BIM, there were 1800 clashes detected and resolve during design stage. One of the objectives on BIM uses in this project, to minimize rework and design change had been achieved with the clash detection analysis [14]. According to the project consultant, the increased quality of installation process results in reduction of Variation Order (VO), thus avoiding the increase of construction cost [15].

3. Methodology
In order to achieve the objective, qualitative approach was chosen as it is a process of naturalistic that seeks to have an in-depth understanding of social phenomena within their natural setting [16]. It ensures the study to obtain in-depth information on the BIM.

3.1. Population and sampling
In statistics, population refers to the discrete group that can be at least identified by one characteristic. For the population of this study, it includes BIM users in Malaysia. In this study, sampling group consists of personnel from different companies that use BIM in their project in which the companies are located in Selangor. These personnel are assistant BIM manager, senior manager and chief executive officer.

3.2. Instrumentation
Instrumentation is referred to the method or approach in conducting research. Instrumentation was meant as data collecting medium to achieve the objective needed. Correct instrumentation is essential in completing a study. In this study, semi-structured interview method is used to collect necessary data for this research.

Semi-structured interview is used to collect necessary data for this research. Semi-structured interview is a method consist of open-ended question asked to a target or sampled group. This method was used when the chance to meet the respondent is limited. The open-ended question list emailed to the respondents prior to the interview. The data is recorded during the interview process.

3.3. Data analysis
Data analysis is the act where data obtained is generalized and hypothesize to ensure the objective is achieved and eventually have a better understanding of the issue. In this study, Matrix Table is used to analyse the data. This can ensure data obtained is organized into more orderly fashioned making it easier for data interpretation and answers accordingly to each respondent interviewed.

4. Results and discussion
This section divides into two main sub-sections which are the cost-related issue for BIM implementation into the project and the influence of BIM in the overall project cost.

4.1. General information on the respondents
In this section, general information on the respondents involved in the research is stated. This comprises the position, years of experiences in the industry, project type involved and project size determined by cost as shown in Table 2. All of the respondents chosen are in the top management level position with working experience for more than 5 years. Therefore, the data obtained from the interview is reliable.
Table 2. Position and experience of respondents involved.

| Respondent | Experience | Position          | Project Type                                      | Project Size             |
|------------|------------|-------------------|--------------------------------------------------|--------------------------|
| 1          | 17 years   | Sr. Manager       | Commercial, Hospital, School, Prison, Residential | RM500 million to RM 65 billion |
| 2          | 28 years   | Chief Executive Officer | Infrastructure, Transportation, Township, Building, M&E | RM20 million to RM 35 billion |
| 3          | 6 years    | Assistant BIM Manager | Infrastructure, High Rise, Mix Development        | RM300 million to RM20 billion |
| 4          | 7 years    | Assistant BIM Manager | Sunway Pinnacle, Sunway Medical Phase 3, Sunway Pyramid Phase 3, MRT Line 2 | RM450 million to RM 55 billion |

4.2. Cost-related setbacks in BIM projects

In this section, the data is analysed from the scope of cost-related issues that may arise in BIM implementation project and the severity of the cost-related issue in the project. The result is shown in Table 3.

Table 3. Cost-related issues and its severity in BIM projects.

| Respondent | Cost-related Issues                                      | Severity of Cost-related Issues                      |
|------------|----------------------------------------------------------|------------------------------------------------------|
| 1          | • Software and hardware cost                             | • It is a one-time cost only                         |
|            | • Provide training cost to staff                          |                                                      |
| 2          | • The infrastructure or setting up of the BIM platform and facilities | • ‘Start-up” expenses (setting up) are a norm in any industry. |
|            | • BIM Consultancy fees                                   | • The BIM consultancy fee is typically part of the contract cost. |
|            | • Control of project cost estimates and variations thereafter. |                                                      |
| 3          | • Underestimation of cost for required BIM manpower       | • Expectation of BIM deliverables is unrealistic where it will be taking a longer time than the conventional process. |
| 4          | • BIM software and hardware cost is very high.           | • One-time cost                                      |
|            | • Hiring BIM expertise need high cost                     |                                                      |

Based on Table 3, both Respondents 1 and 4 highlighted the main concern for the cost involve for implementing BIM are the soft and hardware cost and the training or hiring the BIM expertise. Respondent 4 also reinforced that to hire a BIM expertise required a higher cost than a conventional CAD operator. It is the most common reason for the construction personnel to continue with the conventional method with their project despite the numerous benefits that BIM can provide.

On the other hand, Respondent 2 pointed out the setting up cost that may increase the overall project cost. Respondent 2 further added that the fees required are such as the consultancy fee on the modelling, simulation or even auditing and the estimation cost on the control of project cost and possible variations that may occur in the project.

Besides that, Respondent 3 stated that it is often being underestimated manpower cost required by BIM implementation. A huge number of BIM expertise needed may incur the unexpected additional cost increase and leave the project potentially delay due to the lack of manpower during the BIM work process.
Although there are several cost-related issues and concerns mentioned by all the respondents, yet, most of the respondents gave an optimistic comments base on the severity of the cost-related issue that may face for the implementation of BIM into construction projects.

Respondents 1, 2, and 4 agreed that even though there are cost-related issues for the implementation of BIM, however, it will only affect at the initial stage of the project. This can be seen when Respondents 1 2, and 4 mentioned that it is only one-time cost required to pay for the implementation of BIM. While Respondent 2 also added that setting up cost is the norm and does not bring huge impact to the industry.

Only Respondent 3 still reported that due to high volume information required, BIM deliverability will be much slower than conventional process as there is underestimation in BIM manpower and personnel as well as costing to fully operate it.

Nowadays, it is inevitable to encounter the cost-related issue regardless it is a conventional project or BIM implemented project. Every project has its own difficulty to achieve its final goals. Just as the respondents mentioned, the initial set up cost for the BIM project is higher compared to the conventional project. As the implementation of BIM is still considered as new technology or system in Malaysia construction industry, therefore, the initial set up cost is unavoidable. However, in long a long run, the implementation of BIM is a good investment as the setup cost is a one-time payment. When there is more cost being saved in large construction projects, it will in turn help to gain more income. Moreover, hiring BIM expertise or BIM consultancy fees is a fixed cost that could be estimated.

Apart from that, there are many BIM software packages to choose in the market. If the market worries of no standard guideline, they can choose the more common software such as Revit, thus, it may ease the workflow and reduce the concern of over-budget spend on the hire many expertise. Thus, the cost-related issues highlighted by the respondents in implementing BIM in a construction project are non-disturbing and able to gain more benefits from it.

4.3. BIM’s positive influence on the overall project cost

In this section, the positive influence of BIM on the overall project cost is determined through the respondents’ opinions on BIM implementation to eliminate the cost issue and the perspective of BIM in terms of cost performance.

Based on Table 4, Respondents 1 and 3 mentioned that there is a plausible possibility to eliminate cost issues with BIM usage while Respondents 2 and 4 stated BIM does improve in terms of cost issue.

Both Respondents 2 and 4 mentioned that BIM manages to eliminate the unnecessary cost through more precise estimation checks on the generated model and visualize site condition in advance. Therefore, it reduces the additional cost incurred due to abortive work on-site is avoided. As for Respondent 2, BIM identifies gaps prior to the worksite, hence, capturing possible deficiencies and in turn avoid variation in cost. Respondent 2 also stated that BIM identifies cost in every aspect including procurement, design and construction stage of project whereas Respondent 4 stated the 3D modelling need to be done correctly in order to extract the respective information from the model.

Respondent 1 and 3 are being conservative towards the benefits of BIM implementation can help to eliminate cost-related issues. This is because Respondent 3 considers that the cost performance upon BIM implementation depends on the experienced and skilled BIM expertise to manage the project cost. Respondent 3 added it could be beneficial in a large project. Furthermore, Respondent 1 has consideration that all info in the BIM model is upfront, the cost is corresponding to changes of design therefore cost issue might not be totally eliminated with BIM. However, Variation Order cost can be extracted upon changes on the updated model which can be referred as an alteration to the scope of works in a construction contract in the form of an addition, substitution or omission from the original scope of works.
Table 4. BIM impact on the elimination of cost issues and respondents’ perspective on BIM in cost performance

| Respondent | Elimination of Cost Issue | BIM in terms of Cost Performance |
|------------|---------------------------|----------------------------------|
| 1          | Maybe                     | • VO or “Variation Order” cost can be extracted as model updated upon changes. |
| 2          | Yes                       | • Great advantage in its ability to capture the cost in every aspect  
                     |                          | • It allows construction progress to be monitored effectively and accurately.  
                     |                          | • It also aids in identifying gaps prior to works on site |
| 3          | Maybe                     | • BIM is more beneficial on large scale project; or applied on all project from a consolidated core experienced team. |
| 4          | Yes                       | • The BIM model can only extract the information when the 3D modelling process is done correctly. |

As BIM maintains the workflow of the project, the amount of rework and reinstallation of a component of the building can be avoided. This, in turn, eliminates any additional cost regarding resources and time. Thus, cost performance would be maintained by the implementation of BIM in construction project despite most of the potential is currently stressed on design and 3D modelling. If 5D BIM were to apply on projects, the potential can be further enhanced, thus providing a more reliable BIM system that could benefit another aspect in terms of costing digitally which is parallel to achieving of IR 4.0 in Malaysia.

5. Conclusion
Several cost-related issues on BIM implementation were addressed by the respondents in this research via semi-structured interview. Despite all the issues, most of the respondents do not consider those cost issues as huge concerns to the project workflow. The cost issues were simply taken as merely a one-time cost, where the initial cost of BIM implemented project is higher than conventional project. For industry point of view, the price to pay for the initial cost is worthwhile especially in the long run as BIM has managed to reduce variation of cost in future stages of construction and also save unnecessary cost with reduced time of project. These findings drive implication on pushing the construction industry to adopt BIM. As mentioned earlier, the BIM adoption rate is relatively low in Malaysia and cost issue is ranked first place as challenges to adopt BIM [2]. The result change stakeholder’s perception that BIM is expensive and have a better understanding that BIM implementation cost will not be charged throughout the project.

Findings from this paper show that BIM eliminates additional cost with estimation check, which insinuates an opening to 5D BIM implementation to the construction industry in Malaysia. Apart from that, BIM aids project cost manager to have full control on project budget as any alteration is reflected on budget through BIM tools. The cost performance of BIM project was in the level where it is beneficial to the flow of project and variation control. BIM has an impact on overall project cost in terms of designs and option decision. Cost performance on BIM project is benefited through iterative analysis in design stage and also transparent to the stakeholders through model visualisation. Thus, BIM eliminates the cost of rework and cost overrun due to inadequate design with precise cost estimation.

It can be summarized that BIM implementation is beneficial to project cost planning and management. As mentioned earlier, the cost issue is a one-time cost in equipping BIM system whilst BIM implementation cost involves only a small percentage of total project cost. In a nutshell, BIM is a solution instead of a setback to the project cost issues in Malaysia.
Acknowledgement
Acknowledgement is given to the Ministry of Education under Tier 1 (H190) Grant. We would like to thank Universiti Tun Hussein Onn Malaysia (UTHM) for the technical support.

References
[1] Enshassi A A N 2009 Journal of Financial Management of Property and Construction 14 2 pp 126-151
[2] CIDB 2017 Malaysia Building Information Modelling Report 2016 ed Ismail E et al (Kuala Lumpur: Lembaga Penggunaan Industries Pembinaan Malaysia) p 17
[3] International Monetary Fund. Retrieved from Real GDP Growth: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD, 2018, March 23.
[4] Ramli M 2003 The need for systematic project management in construction industry Malaysia Macroworks
[5] Talukhaba A A 1988 Time and Cost Performance of Construction Project (University of Nairobi)
[6] Kaming P F 1997 Construction Management and Economics 15 pp 83-94
[7] Isikdag U and Underwood J 2009 A Synopsis of the Handbook of Research on Building Information Modelling no. December 2009 pp 84–96
[8] Kamardeem I 2010 Proc 26th Annual ARCOM Conference 6-8 September 2010 Leeds UK, Association of Researchers in Construction Management pp 281-289
[9] Smith P 2014 Procedia - Social and Behavioral Sciences 119 pp 475-484
[10] Azhar S 2011 Leadership Manage. Eng 11 3 pp 241-252
[11] BIMinNZ, “Case Study :Ara Institute of Canterbury Kahukura Block”. Retrieved from BIMinNZ.co.nz: https://static.squarespace.com/static/57390d2c8259b53089b6f066/t/581117rf725e250420e10c299477515049083/7+B+ara+Institute+Canterbury.pdf, 2015.
[12] Tahir M M, Haron N A, Alias A H, Al-Jumaa A T, Muhammad I B and Harun A N 2017 In IOP Conference Series: Materials Science and Engineering 291 1 012009
[13] IBS usage in Malaysia’s construction sector still low: MIDA. Retrieved from New Straits Times: https://www.nst.com.my/news/2015/09/ibs-usage-malaysia’s-construction-sector-still-low-mida, 2015, May 11
[14] Aryani S M 2013 International Journal of Construction Engineering and Management pp 1-6
[15] Ahmad L A, Mohd S, Brahim 2014 Sustainable Solutions in Structural Engineering and Construction pp 753-749
[16] Utah U O 2002 “What Is Qualitative Research? Retrieved from University of Utah College of Nursin”:https://nursing.utah.edu/research/qualitative-research.php. 2002.