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Article

Assessing BIM Adoption towards Reliability in QS Cost Estimates

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Abstract. BIM technology has been evolving around the world in recent years. As in Malaysia, the country has initiated BIM in its current Construction Industry Transformation Programme (CITP) 2016-2020. One of the CITP agenda is to encourage BIM usage to assist the construction players in improving their current practices towards better productivity, hence better sustainability within the construction industry. In quantity surveying field, the technology potentially helps the Quantity Surveyors to accelerate the process of taking-off building quantities, subsequently establishing more reliable and sustainable cost estimates. Although BIM is claimed to upgrade the conventional methods of the measurement tasks, there are still some limitations of BIM innovation, with previous studies lacking explanation in identifying those issues. Therefore, this study aims to investigate the effectiveness of using BIM to aid Malaysian Quantity Surveyors primarily in cost estimating towards composing sustainability elements in the construction industry. To achieve this, a series of focus group discussions were conducted amongst BIM and non-BIM users. Through content analysis, it resulted that the capabilities of estimators in occupying BIM is critical to accomplish the sustainable benefits of the technology. It engages skills in both technology usage and traditional methods of measurement to achieve holistic knowledge of building construction. Thus, it enhances the performance of the estimators to likely generate reliability and sustainability in their cost estimates. This study contributes towards better understanding of cost estimating incorporating BIM and sustainability settings in quantity surveying practice.

Keywords: Building Information Modelling, Quantity Surveyors, cost estimates, reliability, Malaysian construction industry.

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1. Introduction

It becomes crucial responsibilities of the Quantity Surveyors as estimators to certify that the proposed construction projects are within their client's budget [1]. There are various methods for traditional cost estimating process for the estimators to deploy throughout the design and construction project development [2-7]. As the estimated costs will be used as a tender basis as well as for a reference for future project management, preparing for the reliable and accurate ones is very challenging [8]. Therefore, choosing the right cost estimating methods and improving its process and procedures are important to improve the reliability and accuracy of the cost estimates [9]. There are also numerous factors influencing the reliability and accuracy of cost estimates within construction projects reported [9-22]. Those factors should be intensely acknowledged by the estimators before any estimates to attain clients' satisfaction concerning their aimed profit.

Despite having all factors considered, the estimating practice and procedures are still continuously hit by errors, inaccuracies and ommisions; however, BIM technology becomes the significant solution towards these challenges [13]. It is indisputable that through its data visualisation, reliable database and data coordination, the BIM models permits a better production quality of data for the construction projects [23-28]. Yet in adopting the technology for cost estimation, there are some concerns with regards to providing the digital models with necessary information for the desired project [29]. For the estimators to conveniently understand the actual construction process on site, it is necessary that the BIM models adequately epitomise the exact proposed building [30, 31] Accordingly, the BIM modellers should necessarily provide frameworks for model data to identify variables used for estimating purpose to serve as an BIM interoperability platform for information exchange amongst disciplines [13].

Many countries around the world are actively establishing BIM in their respective regions. Malaysia, driven by the national agenda of the Construction Industry Transformation Programme (CITP) 2016-2020 to improve productivity in the construction industry, is also broadly promoting BIM usage amongst its construction players [32]. However, the implementation remained at low level [32, 33] where indicated the needs for some solutions towards this issue. Therefore, by focusing to quantity surveying practice in Malaysia, this study aims to explore the possible effects of BIM usage and its effectiveness in facilitating the Quantity Surveyors essentially in estimating costs for construction projects. There are lack of studies considering BIM improved information through its data visualisation, reliable database and data coordination to facilitate the Quantity Surveyors as estimators to establish costs' reliability and accuracy in their practice.

2. Literature Review

2.1. BIM Data Visualisation, Reliable Database and Data Coordination in Improving Information within Construction Project

The technology of BIM indeed facilitates to produce a better quality of data for construction project documentation [23-28] The visualisation application channels information more effectively as compared with reading single raw data; leading to greater understanding and delivery of the information ([34]. The BIM visualisation models exemplify not only building properties but also their interaction and movement simulation, which can be used at any stage of the construction projects [35, 36]. The model's ability to visualise the construction sequence allows the construction team to better envision of what they intend to build [37, 38]. Apart from demonstrating clearer visualisation rather than using disputable 2D drawings [39], the rich 3D design authorises building views and its contents at all angles simultaneously [40]. It exquisitely facilitates in clash detections of building elements, permitting any related issues to be rectified at an earlier stage to avoid further costly design changes.

The BIM model acts as a database supplying information integrating engineering and architectural building elements [40, 41]. The database is developed based on its proprietary classification system having compatibility with the Industry Foundation Classes (IFC) format [30]. The IFC that captures both geometry and properties of intelligent building objects allows information sharing across the stakeholders [40]. Where the intelligent model can create relationships between components depending on data provided by the designers, the entire information is stored in the libraries and are incorporated in a single BIM file. Any changes made to the model alerts the users, therefore permit them to not only generate data but also to update any sub-sequential attached data automatically [42, 43]. Therefore, the robust platform placing all information gathered from all disciplines will keep the construction team more efficient by enhancing the communication of information throughout the project.

In comparison with the paper-based drawings that are difficult to synchronise, BIM model becomes a solution towards better data coordination within the construction team [43]. With the users creating 3D elements through related BIM software and assembling them in a single model, demonstrating multiple views are possible. The data from building plans, sections and elevations reflected from those views are coordinated, thus improves the coordination of information exchange amongst all team disciplines [44, 45]. The coordinated information delivery further enhances the construction documentation towards decreasing errors and reworks [46-51]. The federated models of design and construction examines clashes simultaneously between the elements of architectural, structural, mechanical, electrical and plumbing systems [43]. Where the installation of all related equipment, fixtures, pipes, ducts, conduits, structural members and

other building components are being analysed with "clash detection" tools [52], the mechanism benefits the team members in monitoring each area through the sufficient information they have, to eliminate unwanted conflicts throughout the project [53]. Anyhow, the users should carefully examine some requirements in the BIM-based process before the technology is implemented, specifically on the sufficient information to be included in the model [29].

2.2. BIM Improved Information for the Development of More Reliable Cost Estimates in Quantity Surveying Practice

The closer the cost estimate towards true probability, the more confidence is rested in the estimate [54], as the estimate's reliability is measured by the confidence level associated with the range of the estimate's accuracy [16]. As the reliability of cost estimates is greatly influenced by the nature and the quality of information available [13], the cost data for the desired project should be reliable and updated [17]. There is a positive correlation between supplied information throughout the project stages and the estimates' accuracy [7, 55]. Hence, the expected estimates' accuracy and reliability defines the quality of the estimates, in which the quality further affects the capability of the estimators in forecasting the future project costs [16]. Apart from the availability of data to estimate costs, the estimators also depend on their skills and judgement towards establishing costs' reliability [56].

When updated project information becomes the essential element in estimating cost that facilitates the estimators to produce more reliable cost estimates [13], [17], the BIM technology that highly depends on accurate and complete 3D models, brings benefits more than traditional estimating method [57]. The advantage of employing BIM model-based estimating processes is relied on its capability to reduce time of building measurement by manually using 2D drawings [58]. BIM-based estimates that directly connects prototype building model and planning software, provides sufficient details for the designated project for different stage of measurement, allowing easy data extraction rather than typical calculation via conventional techniques [30]. Shen & Issa (2010) explained on the capability of BIM visualisation to enhance the performance of entry-level estimators to contemplate more complicated estimating tasks [59]. Cheung et al. (2012) described the ability of BIM database to synchronously identify and update any changes of building construction in parallel with the design development, to further automate building quantities measurement [60]. Whereas, Chen (2013) in estimating the quantity of reinforced concrete, demonstrated that higher estimates accuracy was obtained by using BIM-based method as compared to applying the conventional approach [61]. Others affirmed that BIM mechanism effectively reduced human errors due to omissions and miscalculations in estimating the building costs by using traditional process [61-63]. The BIM usage has been widely reported in quantity surveying practice across the globe, particularly in helping to develop more reliable cost estimates [64-68]. BIM-based construction projects involved significant roles of the Quantity Surveyors as estimators specifically in materials take-off [64]. Olatunji et al. (2010) emphasised that the technology does not threaten the quantity surveying practice, rather the technology endures limitations to be overcome by the users [69]. Although having BIM as a medium of assisting most of the work practices, the duty of the Quantity Surveyors as cost advisors for decision-making during the design and construction development is critical [28]. Boon & Prigg (2012) proclaimed that to make the estimating process more efficient by employing the BIM application, it must be supported by competent Quantity Surveyors in using the digital software [66]. However, there are some limitations in conducting this mechanism effectively in quantity surveying practice and lack of studies investigating on this issue.

3. Methods

3.1. Participants

The focus group panels were selected based on criteria of their working experience in construction cost estimating, professional background, current roles in organisations, and nature of their current organisations' business. To have diversified perspectives of cost estimating practice with BIM judgement, there were two sets of focus group established consisting five participants of BIM and six participants of non-BIM users respectively [70]. However, the criteria in terms of working experience between both groups was different to some extent, due to the difficulties of obtaining BIM users having more than three years of experience in estimating construction project costs. Other than that, all participants chosen were qualified towards the criteria outlined, as presented in Table 1 below. Purposive sampling [71] was adopted where the potential participants listed from the Board of Quantity Surveyors Malaysia (BQSM) locating around Kuala Lumpur & Shah Alam were contacted. However, due to poor feedback from contacted respondents, snowball sampling technique was carried out in which additional participants were recruited with assistance from the earlier ones [71].

3.2. Instrument

The focus group conversations were facilitated mainly with audio-recording; nonetheless employing note-taking as an alternative in case of malfunction of audio-recorder while acquiring information from the discussion. Prior to the intended discussion, every panel was provided with a set of documents containing a consent form, a sign-in sheet, an evaluation form, and A4 papers. An interview guide was used to lead every session, consisting of a set of designated questions pertaining to the purpose of this study. There were two main issues within the developed questions considering on: (1) To what extent BIM data

visualisation, reliable database and data coordination improve information for developing cost estimates; and (2) To what extent BIM data visualisation, reliable database and data coordination that improve project information, enhance the understanding and knowledge of cost estimators to establish more reliable cost estimates.

Table 1. Selection criteria of focus group participants.

Selection Criteria	Group 1 (BIM users)	Group 2 (non-BIM users)
Working experience in construction cost estimating	More than three years (with BIM experience)	More than ten years
Professional background	Quantity Surveying, Project Management, Building Construction, Civil Engineering, etc.	
Current roles in organisations	Quantity Surveyor, Project Manager, Construction Manager, Contractor, Civil Engineer, Architect, etc.	
Nature of current organisations' business	Quantity Surveying firms, Contractor firms, Government agencies, etc.	

3.3. Focus Group Procedure and Analysis

This study exploited the steps by Stewart et al. (2007) in conducting the focus group processes [72]. Initially, the purpose of conducting focus group was defined leading to determining the sampling frame [72]. The set of samples were informed through emails and telephones on their consent to be involved in the focus group discussion at specific date, time and place, and also certain requirements that need to be fulfilled by them. Generating and pre-testing the interview guide was then administered in relation with the issues to be discussed during the focus group sessions. While a specific moderator should have been assigned concurrently with designing the interview guide [72], this study however has not appointed any moderator due to time and cost constraints [73]. After all, the prearranged focus group were performed appertaining to specified setting. The discussions were assigned in an environment where balanced seating arrangement was provided that allow all participants interacting each other effectively by maximising eye contact. Every session was started with a clear explanation on the purpose of the study in the opening speech, further followed by the actual discussion amongst the participants, and finalised with a debrief session for the whole discussion. Each discussion was expected to last for one to two hours. It was organised in a way that every participant was able to freely respond to each other's answers without any particular order and agreeing to other people's views. The raw data obtained from the focus group discussion was eventually processed and interpreted by using content analysis method [74]. Final results and findings were established leading to making ultimate conclusion for this study.

4. Results and Discussion

The following results and discussions were drawn from the focus group protocol underlying the inquiries of "To what extent BIM data visualisation, reliable database and data coordination improve information for developing cost estimates?" and "To what extent BIM data visualisation, reliable database and data coordination enhance the values of input information, understanding and knowledge of cost estimators?"

4.1. To What Extent BIM Data Visualisation, Reliable Database and Data Coordination Improve Information For Developing Cost Estimates?

Regardless BIM or non-BIM users, the participants in both focus group sessions were agreed on BIM capabilities through its data visualisation, reliable database and coordinated data could upgrade project information for cost estimates formation. Visualising available project data through 3D models could demonstrate actual building design and construction. Therefore, provides the users more accurate data, better understanding and interpretation towards the project. As portrayed by the non-BIM users group, envisioning a construction project through 3D modelling is a sophisticated approach replacing the traditional drawings. The difficulties in the building structures especially the complicated arrangement of the electrical, mechanical and plumbing works cross-sections could be presented better through the digital modelling rather than performing through manual 2D drawings. Therefore, the virtual drawings should provide greater information for better clarification towards cost outcomes of the desired project.

"Virtually, besides cost data, BIM provides visual information as well, in the forms of drawing. Previously, information is based on hardcopy, now the information is based on softcopy. You can actually go through the building itself, you can visit, etc., digitally. So, it should provide better understanding with regard to visualisation… with 3D visualisation, it helps a lot the MEP with architectural and structural, to allow connections for the piping… We can see the cross-section from the model visualisation… with regard to understanding on the difficulty/shape of building itself, in which affects the cost of the building…" - non-BIM user

Similarly, the BIM users claimed that BIM models supply more details than 2D drawings. Although the conventional drawings could also allow visualisation for the building construction, however they are not as extensive as the digital models that demonstrate the actual multiple views for the project. The information furnished by the models becomes more accurate as data is progressively updated where all errors and changes are detected earlier. BIM models resembling actual building demonstrate direct views that facilitate the taker-off to acquire more confidence in measuring building quantities and its costs, especially for complex configuration.

"When we have BIM, we see more details through 3D models, as compared to using 2D drawings. So when, we do taking off, estimate, BQ, we mostly do not overlook the information. Due to this, in terms of accuracy, it will be increased. The accuracy of data that we receive… With BIM, we can manipulate the model and see in many views of design and construction. We do not have to rely on the architect to send cross section drawings…When you have 2D, you may visualise but they are not incorporated, as compared to the model…we can double check based on the construction technology. Whether they are some unusual of columns, beams, etc. so, it will help us straight away from the surface of the model, to see that this is how the building looks like. So, the confidence level of the taker-off for the measurement will be there…" – BIM user

Other than that, more reliable database of BIM could contribute sufficient information in which assumptions made while completing taking-off measurement could be lessened; hence improving task performance of the users. For non-BIM users, reliable database means accurate data that has been updated constantly. As for them, the more complete information they receive the more accurate estimate they would produce, as they do not need to presume much on the figures to build up cost for the project. Consequently, the process simplifies their works by diminishing mistakes, further encouraging better cost advice to be constituted.

"One thing about data is it will be reliable if it has constant updating…I think if it has no complete information, it is not BIM. The system tells on dimension, process, and maintenance in 3D which is automatic and transparent…Because you have the data, then you can perform better. Then, easy to understand...If you have a good database, means that it eases your work. And of course, chances to make mistakes are less…if we talk about reliable database, the more information we get, the more accurate is our estimate. Less assumption to make…" – non-BIM user

Likewise, by employing BIM, the users acknowledged that BIM reliable database could develop information from the beginning of the project until the asset management phase, in consequence, enhance the project performance. As cost estimators, the most important part is whether the database could equip them with sufficient information for quantity taking-off purpose. The classifications of levels of details (LOD) in defining information development in BIM procedure indeed facilitates the designers to accomplish accordingly towards accommodating the project with its necessary information.

"There are some levels of details, which we need to divide and which we need to define the model, LOD100, LOD200, LOD300, etc. So, for the cost estimates we are talking about, LOD200 is good enough, to extract information, not complete but at least you can extract information… Better task performance is, if you can use BIM continuously towards the end of final account. One BIM model can be manipulated until end of contract. In other stages of construction project..." - BIM user

Additionally, data coordination accomplished from BIM models could permit sharing and integrating information amongst the disciplines in the project team, leading to achieving a collaborative goal within the stakeholders to establish more accurate project costs. In defining integration of project information, the non-BIM users emphasised that the project team should not work individually, rather to communicate each other throughout the project progress. Coordination requires all disciplines to be efficient and recognise their responsibilities respectively at an early stage of project design. This would shape a co-operative environment within the team that might dilute misconceptions, thus increase accuracy in their practice. Silo-effect within the project operation only encourages the individuals to become too protective with their own data, neglecting to share with others.

"The integration. The consultant must be competent in order to design at early stage…So that the planning can help to reduce discrepancies in construction stage…The goal is less mistake…Main goal of course, we can give accurate estimates…Less mistake increases accuracy even though not 100%. We are professionals; we need to guarantee the accuracy, or else we need to bear the errors…If we do works in isolation, everyone is very protective with their data. So, at the end of the day, it is self-satisfaction, but not others…" - non-BIM user

According to the users, the BIM technology doubtlessly advocates an effective surroundings of data coordination and integration amongst team members. Later, the information could be adequately shared and communicated for further usage, such as cost estimation. Simultaneous viewing of data gathered from all related disciplines through BIM platform detects incompatibility between building elements of architectural, structural and mechanical & electrical (M&E). Where these data discrepancies should be rectified earlier, it creates clash-free information for the project, in which the users could depend for their cost estimating tasks.

"During the collaboration before the project starts, the designer in particular the architects, should actually tell them about BIM and ask them to get some information on what is the software they are going to use. Whether they can share information through the software they are using. For example, architect, structural use Revit. How about M&E? They must be coordinated. Because that is the purpose of BIM, to collaborate one another. If they are not using the same

platform, they can't talk to each other…So the structural, M&E and architectural actually are the ones who coordinates one another. To do the process of clash detection, to double check…We truly take time to develop the model, but in the end, clash free…" – BIM user

To certain extent, data visualisation, reliable database and data coordination through BIM mechanism undeniably could enhance information to be manipulated within any construction project, including cost estimating phase. Additionally, for developing project cost estimates, undergoing BIM process accelerates the estimating procedure by decreasing errors and changes, hence saving time and cost at some stages. The following discusses on how would the BIM capabilities of data visualisation, reliable database and data coordination that improve the project information, further enhance the understanding and knowledge of cost estimators to establish more reliable cost estimates.

4.2. To What Extent BIM Data Visualisation, Reliable Database and Data Coordination That Improve Project Information, Enhance the Understanding and Knowledge of Cost Estimators to Establish More Reliable Cost Estimates?

BIM capabilities of visualising data effectively, providing more reliable platform of database, and integrating such coordinated data amongst the disciplines in the project team, indeed facilitate the cost estimators in some measures. For example, both groups agreed on the 3D views through the BIM models certainly benefit especially the non-experienced estimator to comprehend the building design and construction.

"Digital information probably may help the new cost estimators to have better understanding compared to experienced estimators…Even though they lack of experience, they can interpret the data, but needs extra effort in understanding design, etc. like when they look at the drawing, plan, and elevation or from sketched drawings, probably they don't understand. But if let say, wherever you have 3D information, there shouldn't be any problem with regard to understanding on the difficulty or shape of building itself, in which affects the cost of the building..." - non-BIM user

"Let's say for the new staff. For them maybe they are still new. So their experience when it comes to building construction is not so high. So, when they see 3D model, then straight away they can see. Sometimes they do understand how to read the drawing. But for them is quite slow to interpret it initially. They know how to measure but they don't know how to interpret. Once the interpretation is wrong, the percentage of them having a wrong measurement is also very high. So when they see a 3D model, they can better understand information inside the building…" – BIM user

However, there were also some challenges outlined by the focus group participants with regards to applying BIM models. It specifically compromises with the capability of BIM technology in improving their understanding and knowledge to establish more reliable cost estimates. In encouraging more understanding of project information via BIM applications, it unconditionally depends upon the details provided by the designers for the BIM models. The non-BIM users emphasised that it is crucial to have detailed information and reputable sources before any cost estimates to corroborate its accuracy and reliability. BIM models could defeat the limitation of using historical data from past project to generate cost assumptions; provided that the designers contribute adequate information towards their designated models for relevant purpose.

"At the end of the day, it depends on how the designers provide the details, as the details are very important. Without the details, you will do lots of assumptions. Sometimes, estimator is assigned from the very early stage of a project; you must take into consideration that the outcome of first estimate will be on the final cost of the project. We have to commit on what will be the financial issues. It helps with data visualisation…" – non-BIM user

The importance of the designers to furnish sufficient details in BIM models was further explained by the BIM users. Since embedded input in the model determines the received information for the cost estimator's intended usage, it becomes the designers' effort to specify desired information to be included in their respective models. Yet, occasionally, the users have been served by just overloaded details that require time-consuming data selection, or incomplete information that needs related assumptions to project the costs.

"Input given to the model determines information we give. Even though we have standard, we still need to fill intended field to get the information. In the end, it will be partly of human effort to contribute to the development of information. It is difficult to rely on data from the designers. There is not enough information… Sometimes you really couldn't identify until the construction of the building is completed. Design needs to be complete. Our problem now is we can't rely on the engineers, etc. You need to interpret, make your own assumption. This is not flexible. People will easily get impressed with this, but us as QS feel a bit frustrated on this situation…When they give us the data; it is a lot for us. We need to choose where suitable. Sometimes if the drawing is not tally between architectural and structural, it is much more corrupted. Making your design in fault…" – BIM user

Also, the BIM users considered that visualising design and construction of a project through BIM models merely assists to generate automated building quantities for measurement purpose. Built-up rates that deal with other external pricing factors to accomplish project cost estimates are not incorporated within the process. BIM models only mechanise the quantities for the building components but not the operation that makes up the components.

"We can't automatically get all. If we get this, we still need to build up the rates. Means that, it helps us in terms of developing the

estimate, to get the quantities, not directly get the cost. There are lots of factors contributing to the cost. In the model, we are referring to the components, not the works to make up that component. Cost is not something that easy to be done…" – BIM users

This is parallel with the non-BIM users' opinion when it comes to applying BIM technology to build-up the project costs. After all, the BIM mechanism can possibly be exercised towards providing more accurate building quantities measurement as it partly enriches the information needed in formulating more reliable cost estimates.

"For estimates, I think there are lots of outsourced factors compared to just seeing the 3D or 2D, 5D and so on. It's more than that. But if for taking off, it is possible. It is included in the system. You can view everything. From there, you can take off, it is much easier. Everything seems faster. So the thing being faster only applicable for taking off, not for estimates...The issue is when you said, BIM helps to do the estimates, yes. In terms of extracting the quantities, that is true. It's very good. But there are factors that you need to reimburse, is based on experience. Extracting quantities, yes, but not the price factors…" – non-BIM users

In regards with knowledge, BIM environment within the quantity surveying practice would positively promote the improvement of knowledge in estimating process amongst the cost estimators. Nevertheless, it takes the effort of harmonising both knowledge of fundamental building measurement and skills of using new digital technology such as BIM. According to the non-BIM users, the BIM technology can only be valuable in their practice if they could equip themselves with the capabilities of using digital software, and in the meantime appreciating construction drawings fundamentally for measurement purpose.

"So, probably with BIM, the measurement is simplified by computerisation, no need traditional method of scale rule. But the estimator needs to understand the method to measure. So, reliability of estimate will depend on the knowledge of the users… You can do measurement, and at the same time you can visualise from the digital drawings. Then at the end of the day, we understand… The knowledge should be integrated (able to do estimating, well in computerisation, operate drawings for measurement purpose), and then only this technology is useful. Otherwise, its usage is limited…" – non-BIM user

Equivalently, the BIM users affirmed that before manipulating BIM model for building measurement, they need to be aware of fundamental method using conventional drawings. Despite the possibility of having BIM model where urged information could not be retrieved, at least the users could manipulate their knowledge and experience of traditional measurement to generate the information they need through the digital platform. In other words, to upgrade their cost expertise, they need to well-balance between knowledge and technology to become competent cost estimators in producing more accurate and reliable cost estimates.

"…how to read the 3D model…how to read the 2D drawings…how to get information for this…Because not all information is provided in 3D. But is given, without it, you can't get any information. Details, not everything are provided on the attributes of the 3D model. So training on how to read this, on how to use platforms using technologies. To get this information, all from 3D and 2D, are very crucial…Experience in estimating alone doesn't take up 100% of what you need to deliver. It is something like 50 50. You have this knowledge, you need to use this technology, and you sum up these together. Once you combine these together, then you will become a powerful estimator. You know how to estimate, you know how to measure 2D and you also know how to read 3D model…" – BIM user

In summary, the convenient digital information that could be obtained from BIM models, at some point, may facilitate the cost estimators to improve their understanding and knowledge towards establishing reliability in their cost estimates. However, some issues need to be firstly rectified to avoid the failure of utilising the technology effectively. Despite the models being provided with appropriate information; not only the users themselves must be capable to employ related digital software, but they also need to be knowledgeable in comprehending the conception of construction drawings substances.

5. Conclusion

This study explored the potential of BIM technology in demonstrating the reliability of cost estimates from the perspectives of Malaysian Quantity Surveyors. Through the focus group discussion, regardless BIM or non-BIM users, the participants have acknowledged the BIM benefits towards improving their roles as cost estimators. Visualising project information through BIM model perhaps cultivates more understanding amongst estimators in developing more accurate and reliable cost estimates. The process is further enhanced by the assistance of BIM reliable database and coordinated data to make the process more effective. With the BIM model prototyping the actual building design and construction views, it could generate sufficient information needed by the users. Additionally, the coordinated data from the BIM mechanism possibly accommodates a better platform for all disciplines in the project team to share and integrate information throughout the project cycle. Therefore, it creates more interactive environment towards achieving the goal of inaugurating more reliable information within the stakeholders.

Anyhow, the participants were also cautious about some limitation of the technology that could affect the performance of their cost estimating practice particularly in improving their understanding and knowledge. The technology becomes impotent when it supplies overloaded data that requires the users to dependably

excerpt the ones they need. Whereas, the possibility of insufficient data provided by the BIM models leads to more assumptions made prior to establishing project cost estimates. Due to this, there are some BIM model requirements that need to be attentively considered by the users before deploying the model to fully utilise it for information extraction. It is the designers' responsibilities towards contributing sufficient data to the BIM model for it can be fully utilised by the users for further significant usage such as estimating project costs.

It was also indicated that the technology solely is inadequate to accomplish accurate costs. Although BIM innovation could potentially generate reliable take-off quantities, pricing any construction projects requires some other external pricing factors demanding the estimator's judgement. Nonetheless, adopting BIM in the cost estimating procedures could still partially facilitate the estimators in obtaining more accurate and reliable building quantities measurement for subsequent cost estimates. By any means, the effective usage of the BIM is depending on the users to suit the technology with their existing knowledge of fundamental building measurement. The novelty of this study relies on the contribution towards establishing the strategies of incorporating BIM technology in improving cost estimating practice by the Quantity Surveyors. It specifically focuses on the capabilities of the estimators themselves to not only strengthen the skills of traditional building measurement, but also to adept the knowledge of digital software within the new technology of BIM.

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