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Client Governing Success Criteria in Building Information Modelling (BIM)-Based Projects

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Abstract: Building Information Modeling (BIM), also known as n-D Modeling is a revolutionary development in the Architecture-Engineering-Construction (AEC) industry that consists of both technology and process. BIM helps project stakeholders in communicating complex, technical and difficult to visualise project elements that not easily explained. Nevertheless, there is a lack of overall governance within the current projects environment. A successful BIM implementation needs the involvement of behavioural, cultural and technological changes to transform the organisation into BIM-based projects through adopting new processes and standards. Thus, it is inevitable to develop a governance solution to facilitate BIM adoption in a collaborative working environment across project lifecycle. This paper discusses a success measure of BIM-based projects in Malaysia. The methodology is based on a qualitative research technique and the method is through a well-planned brainstorming workshop. All data were analysed using Atlas t.i. version 8. The findings revealed that four (4) success measures of BIM-based projects are: socio-organisational, legal, technical, and financial. It is anticipated that the findings reported in this paper could provide an insight for future strategies and guidelines for the development of BIM projects in Malaysia. BIM governance framework proves to be valuable for project stakeholders in managing collective efforts to standardise construction processes.

Keywords: Building Information Modelling (BIM); Client; Governance; Malaysia; Success criteria

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1. Introduction

Construction industry projects involve complex activities, thus its need for collaboration among the team members working environment in the Architecture-Engineering-Construction (AEC). BIM team collaboration is defined as, “the agreement among specialists to focus their abilities on a particular process to achieve the longer objectives of the project as a whole” (Hobbs, 1996). Collaboration involves an interaction through; communicating, exchanging, coordinating, and approving in order to maximise the team’s effort on a particular work task (Ilich, Becerik, & Aultman, 2006). According to Alreshidi, Mourshed, & Rezgui, (2015), many collaboration solutions had been developed to facilitate the collaboration issues in the construction industry. Nevertheless, to date the government of Malaysia failed to address governance particularly in the context of BIM in the construction sector. Based on above definition, BIM allows the team members collaboration throughout all project lifecycle that enabling the team members to insert, extract, update, and modify the information during the BIM processes. BIM emerged as a new way of managing information flow during the project lifecycle (Motamedi & Hammad, 2009), offer many advantages such as improved visualisation, cost estimation, quality improvement and facilitating team collaboration.

According to Alreshidi et al., (2015) and Khatri & Brown, (2010), governance is about who and how to make decision, whereas management is the process of implementing those decisions. A successful BIM implementation needs the involvement of behavioural, cultural and technological changes in order to transform the organisation into BIM-based projects through adopting new processes and standards (Jones & Laquidara-Carr, 2015). As such, it is a need to develop a governance solution to facilitate BIM adoption in a collaborative working environment across the project lifecycle (Eissa Alreshidi, Mourshed, & Rezgui, 2016). From the governance standpoint, there are several requirements to overcome the limitation of team collaboration. These are: (a) socio-organisational, (b) legal, (c) technical, and (d) financial. Hence, the objective of the paper is to access factors of success measures of BIM-based projects in Malaysia.

2. Materials and Methods

The study started with a comprehensive literature search through journals, and related articles, which include: Consult Australia, (2010); Currie, (2014); Gathercole & Thurairajah, (2014); Ghaffarianhoseini et al., (2016); Hobbs, (1996) and reports from NBS, (2013) and Khemlani, (2007). Those literatures exposed that a merely limited number of studies expound the need for the development of BIM governance model to facilitate the collaboration issues. This study is underpinned by the following research question: What are the factors of success measures of BIM-based projects.

The methodology starts by conducting a one-day workshop involving 50 participants (focus group) from Architectural, Engineering and Contractors (AEC) professionals in the Malaysian construction industry. These focus groups were chosen based on the three criteria: sufficient practical experience of BIM; sufficient knowledge of data management and BIM-related aspects: and willingness to participate. The groups were divided into two with 25 participants for each (representing client, consultants, contractors, technology developers and academician) as illustrated in **Error! Reference source not found.**. They are required to identify and discuss factors of success measure of BIM-based projects in Malaysia.

Table 1 - Profile of respondents.

Sample					Experience (Average Mean - Years)	
Type	**Name**	**Designations**	**Expected participants**	**Participants attended**	**Industry**	**BIM**
Public	Government Agencies	Manager	5	4	14	4.5
		C&S Engineer	5	2	7.5	4
		Quantity Surveyor	5	2	8.5	4
		Senior Assistant Director	5	1	12	3
		Assistant Director	5	1	25	7
		BIM Modeler	5	2	6.5	4
	Academia (Local Universities)	Senior Lecturer (BIM)	30	30	13	4
Private	Private Agencies	Design Coordinator	5	1	3	3
		Manager (VDC)	5	1	24	5
		BIM Manager	5	1	10	5
		C&S Engineer	5	1	4	2
		Assistant General Manager	5	1	6	3
		Manager	5	1	9	3
		Managing Director	5	1	16	10

Senior Executive	5	1	23	5
Total	100	50		

Based on the designation and work experience of the respondents, it is sensible to infer that the respondent has a sound knowledge in the construction practices of the respective organisations. The longer experience of the respondents in industry, the greater their understanding of construction practices (BIM). At the end of the discussion, an opportunity was given to the respondents to ask any questions and to add any additional comments. The discussion ended smoothly with outcome presentation for the groups, remarks of appreciation, farewell pleasantries, and explanation of the possibility that they will be conducted for further enquiry and exploration.

The data collected were analysed using content analysis technique. All data then were analysed using Atlas t.i. version 8. Atlas t.i. could process data in which where texts are analysed and interpreted using coding and annotating (Smit, 2002). Furthermore, it provides a comprehensive overview called Hermeneutic Unit (HU) that facilitates an immediate search and retrieval activities. Atlas t.i. program also has a network-building feature which allows one to visually connect with the selected texts, memos, and codes in diagrams.

The next discussion will focus on results and discussion of data collected.

3. Results and Discussion

Fig. 1 shows the network view from Atlas t.i. analysis and Table 2 presents the client governing success measures in BIM-based projects in Malaysia in the form of table. These findings are purely based on the focus group discussion and guided by literature search. Unanimously, they agreed that four (4) factors are taken as success measure of BIM-based projects in Malaysia. These are related to: socio-organisational; legal; technical and financial success measures. The outcomes are discussed in turn.

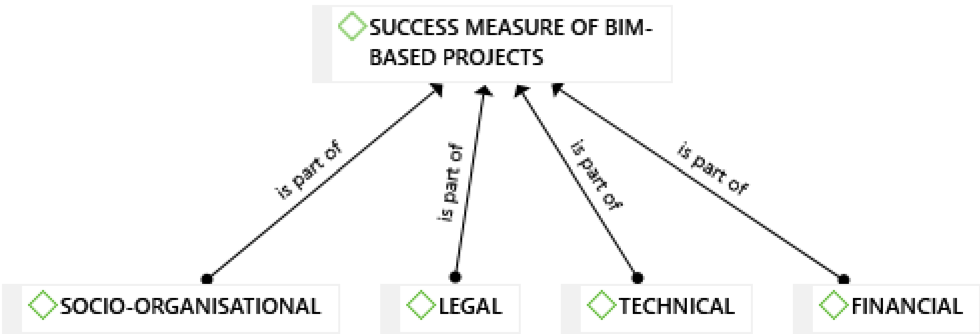

Fig. 1 - View of focused network of success measure of BIM-based projects.

Table 2 - Success measure of BIM-based projects in Malaysian construction industry.

	Group 1	Group 2	Critical Factor
Socio-organisational success measure	• Changes of team members' • Good collaboration • Identical skills and understanding • Team's structure • Organisational cultural values/beliefs • Defined roles and responsibilities	• Changes of team members' • Organisational cultural values/beliefs • Defined roles and responsibilities	• Changes of team members' • Defined roles and responsibilities
Legal success measure	• Collaboration standards • Liability of wrong information • Information ownership and preservation • Intellectual property • Government regulations • Data translation/	• Collaboration standards • Liability of wrong information • Data misuse	• Collaboration standards • Liability of wrong information

	interoperability		
Technical success measure	• Intensive technical training • Compatibility of hardware and software • Compatibility of various standards-based (e.g. IFC products) • Data integrity/user authentication/data security and access control • Privacy of external storage	• Intensive technical training • Compatibility of hardware and software • Privacy of external storage	• Intensive technical training
Financial success measure	• Cost of initial hardware and software costs • Training cost • Maintenance costs (e.g. regular updates of software) • ROI of projects	• Cost of initial hardware and software costs • Training cost • ROI of projects • Costs for shared liabilities policy	• Cost of initial hardware and software costs • Training cost

3.1 Socio-Organisational Success Measure

Table 2 shows the results of socio-organisational as a one of governing success measures (7 nos) in BIM-based projects in the form of: changes of team members'; good collaboration; identical skills and understanding; team's structure; organisational cultural values/beliefs; defined roles and responsibilities; and transition team members'. These seven success measures were discussed as follows:

i. *Changes of team members'*: The company that implementing BIM has to change the work process. The company in entirely, has to be aligned to their value chain process. As shown in Table 2, Manager, Senior Lecturer and BIM Modeller (G.1) indicated that:
'There is a strong need to involve all team members at the early design stages until the completion of BIM projects'.
Several factors need to be considered when working with BIM-based projects especially team members. It is supported by the statement from Senior Lecturer and Design Coordinator (G.2) stating that:
'Team members should adopt and use effective communication, collaboration and coordination practices. They also need to alert of any changes as early as possible.'
Team member's engagement is critical value that include team level trust, common goals, effective communication, collaboration practices, effective coordination, leadership, and common data environment (Eissa Alreshidi et al., 2016). Any changes may occur in all organisation, thus the organisational members are scared to the unknown need to change. To a certain extent, some organisations tend to hide their mistakes in the working process. However, BIM is a safe environment where errors are seen as improvement opportunities.

ii. *Good collaboration*: Collaboration is transforming the construction industry. Collaboration is defined by Merriam - Webster, (2017) as *'to work with another person or group in order to achieve or do something.'* Building projects are highly complex that require unique expertise from variety professionals, hence getting all project stakeholders to work together would bring better results. It is also significant to note that while working with teams; it will involve different culture and traditions which neither unclear roles and responsibilities nor collaboration issues e.g. trust (Eissa Alreshidi et al., 2016). Hence, a good collaboration will bring a construction team together. However, Senior Assistant Director, Senior Lecturer and Manager of VDC Development (G.1) suggestion were contradicted with the literature search where:
'*Despite the adoption of BIM for construction projects promises a good return, the lack of collaborative working environment between stakeholders will deteriorate the project performance in terms of time and quality'*
For example, to transform the 2D AutoCAD to BIM 3D modelling will normally doubling up the entire workload. In the normal circumstances, project stakeholders will work separately as pointed out by Senior Assistant Director, Senior Lecturer and Manager of VDC Development (G.1) that:
'Apparently BIM is able to make all project players to work together, unfortunately for my case, most of them work in isolation in which architect and engineer are still worked in their own traditional way.'
All project stakeholders should collaborate with each other to meet the project goals. BIM Execution Plan (BEP) detailed out the collaboration and communication procedures that necessary for all team members.

iii. *Identical skills and understanding*: The success of BIM implementation will depend on the skill and understanding of the people using the technology. BIM is a revolutionary from drawing production thus imposing a different set of skills and understanding. Roles for BIM experts are required different set of skills. However, there are still shortages of people with deep understanding on how to manage data, including data transferring, data loss and others in order to meet with the client requirements. It is supported by the statement from Senior Lecturer (G.1), Senior Lecturer and Manager (G.2) stating that:

'We want to expand the use of BIM in our organisation, however the problem that we are facing at the moment are lacking of skills to create BIM Modellers or 3D specialist/designers. As such the shortage of skilled people may push up for a greater wages".

In addition to have a BIM competent workforce, it needs an adequate BIM skill to implement BIM effectively. It is supported by the statement from Senior Lecturer (G.2) suggested that:

'BIM education could help employers to prepare graduates for adequate BIM skills to fill the industry's requirements'.

As the industry shift from traditional to BIM working environment, education plays an important role to prepare the students with the BIM skills that will also support their career and project success.

iv. *Team's structure*: There are large numbers of recent studies such as Hore & West, (2008) and Mihindu & Arayici, (2008) that explored how information technologies are reshaping the construction. Nevertheless, the studies are not specific to individual disciplines that are rendered in the construction industry. Hence, Olatunji, (2011) proposed the organisation structure were grouped into four conceptual variables of organisational functionality, namely: matrix, networks, functional, and divisional models. For matrix structure model, project teams are formed through collection of skilled individual from different parts of an organisation in order to achieve corporate goal(s). The result is in line with the opinion of Quantity Surveyor, Senior Lecturer and BIM Manager (G.1) that:

'Our organisation used matrix structure because it optimise teamwork and the individuals responsible to report both of line and project managers. This matrix structure is very relative to construction systems'.

The success of it depends on the project data that need to be shared and managed amongst the project team members. As for network structure model, Sailer, (1978) defines networked structured model as a relationship pattern that combines a set of process nodes (i.e. persons, positions, group, or organisations). However, construction organisations nowadays are fluid and not suitable for network structure model. Moreover, based on Holzer, (2007), not all networked operators and team members are prepared to deploy BIM and may not drive to project success in collaborative environment. Others, for functional structure model, it is divided based on the managers where each line managers will represent professional disciplines (i.e., designers, project managers and others) with distinctive professional responsibilities to achieve project goals. Those managers need to deploy project coordination for the benefit project goals in the long run. As for divisional structure model, it is made to perform specific functions. It is commonly that all organisations have functional divisions to facilitate corporate goals such as technical, marketing, finance, and research and development.

v. *Organisational cultural values/beliefs*: The culture of implementation decides the effectiveness of a new concept. For incorporating BIM, an open-minded culture is required. In the construction industry, where project managers spend most of the time on-site, where they have the liberty to work in their way. In BIM case, however, these project managers need to adhere to strict guidelines and processes and thus, resistance to change. According to Holzer, (2016), BIM Managers play a decisive role as change facilitators. Change facilitators play a role to assist key stakeholders with an organisation by mentoring and guiding them on their path to deal with the change. During the facilitating processes, BIM managers will train, guide, and mentor in order to align the traditional workflows with a new BIM approach. According to Quantity Surveyor, Senior Lecturer (G.1), Senior Lecturer and Assistant General Manager (G.2) highlighted that:

'In Malaysia, the initiatives of individuals of small and medium organisations are able to force these organisations to accept some possible changes in the working environment.'

The introduction of high-end technology for information sharing requires a re-think of established workflows. BIM implies a more structures and less individual-centric approach to knowledge-capture. In short, cultural beliefs, values, and norms constitute an organisation's cultural potency to influence behaviour. Thus, leadership that can identify and influence cultural readiness for change can be a requisite to an effective process initiative. Moreover, open communication and information sharing can promote culture and innovative behaviour among people inside an organisation.

vi. *Defined roles and responsibilities*: Roles and responsibilities are defined and clarified at the early meetings prior to the commencement of the project. The risk of unacceptable errors for stored data will minimise once the access rights were defined at the early stage. The most important key factors for effectively governing the BIM collaborative process are through knowing who, when, and how to work on the model. The Assistant Director, C&S Engineer, and Manager (G.1) defined:

'In BIM, the roles, responsibilities, and duties of stakeholders (such as the BIM manager, architect, engineer, technician, and contractor) are crucial to be identified at the early project phases to minimise an unacceptable errors at the later phase'

BIM-caused differences that will affect organisational structure and the responsibilities of the roles that make it up Gathercole & Thurairajah, (2014) as example shown in Table 3. As pointed out by The Senior Lecturer (G.1), Senior Lecturer, Manager and Senior Executive (G.2), highlighted that:
'If the organisation plans to offer new posts or revamp the existing roles, they need to specify in detail the new job descriptions for the new roles to avoid overlapping work.'

Table 3 - Role classification of BIM job titles (Gathercole & Thurairajah, 2014)

Role	Job Titles included
BIM Manager	BIM Manager, BIM Leader, BIM Consultant, BIM Discipline Head
BIM Coordinator	BIM Coordinator, BIM Implementer, BIM Integrator, BIM Practitioner, BIM Specialist
BIM Technician	BIM Technician, BIM Modeller, BIM Operator
BIM Engineer	BIM Engineer, BIM Architect, BIM Designer, BIM Structural Draftsman

This is in-line with Aouad & Arayici, (2010) claim that *'networking, collaboration, information sharing and communication will become popular and critical issues in the future'*, which Arayici et al., (2011) build on by emphasising as a central theme the argument that *'implementing BIM effectively requires significant changes in the way construction businesses work at almost every level within the building process'*. Meanwhile, Kymmell, (2008) surmises *'three primary BIM-related roles that emerge from (a team selection process) are: BIM Manager, BIM Operator, and BIM Facilitator', correlating the first two to the existing Project Manager and Project Engineer roles respectively) and terming the third to be'*.
Once the roles, responsibilities, and position has been established, these will be documented for the future job designation.

3.2 Legal Success Measure

This section presents the result of discussion for legal aspect of governing success measured in BIM-based projects. Some insights on legal aspect have been expounded by the participants include: collaboration standards; liability of wrong information; information ownership and preservation; intellectual property; government regulations; data translation/ interoperability; and data misuse.

i. *Collaboration standards*: BIM is essentially collaborative working environment. The majority of the respondents admitted that the use of BIM in the construction project particularly the collaboration among the team players is high where the information regarding the projects is understood by each member. Based on discussion, Senior Assistant Director, Quantity Surveyor, Senior Lecturer (G.1), Managing Director, Senior Lecturer and C&S Engineer (G.2) have revealed that:
'In actual fact, the introduction of CAD in the construction industry can efficiently produce 2D drawing and 3D models. However, the new BIM offers a digital representation and allows the team to analyse and visualise design decisions long before a project even breaks ground and becomes the new standard to be adhered. With BIM, collaboration becomes an important factor to support the new way of working. In Malaysia, BIM is considered as new and it is difficult to adopt the concept fully in the right manner. Hence, an establishment of a dedicated team, well collaborated are required to deliver a successful project.
This is supported by Ilich et al., (2006), indicating that collaboration involves people who work together by sharing the same information and process through interacting, communicating, exchanging, coordinating and approving in order for the team members to share the same vision and maximise the team's effort on the particular job.

ii. *Liability of wrong information*: The model is immensely valuable but can be fragile due to software such as power interruptions, viruses, and physical damage. Since BIM is a collaborative work, the ownership of the model may not be invested in a single party. But, if the ownership issue is significant, the project team should determine it by the contract. If the information is confidentiality, appropriate confidentiality agreements should be made to limit the distribution of information among them. This statement confirmed by BIM Manager, Senior Lecturer (G.1), Design Coordinator, Senior Lecturer and Assistant General Manager (G.2) that:
'In the development of BIM procedures, the project team should consider some important factors such as: who owns the model, who owns information in the model, and who are allow to access to the model in order to avoid disputes among them.'
The statement above implies that team members that signing in BIM agreement are making a serious commitment to working together in term of mutual trust and support and reduce errors as little as possible and in line with Rancane, (2014).

iii. *Information ownership and preservation*: The model development, reviewing, uploading, downloading, and analysis activities could be quite complex within an integrated BIM-server environment. Specifying ownership, updating liabilities and responsibilities would need careful consideration. A BIM contract agreement is required which should be signed and agreed upon by the project partners at project initiation. Among other aspects, the legal and contractual support should ensure that the agreements account for (1) intellectual property agreements and policies for data exchange, (2) classification of public and private data, and (3) correspondence protocols as back-up strategies (Singh, Gu, & Wang, 2011). Based on the discussion, Manager of VDC Development, Manager, Senior Lecturer (G.1) and C&S Engineer (G.2) has revealed that:

'Once the BIM agreement has been agreed upon, by and large all stakeholders are required to adhere and update information from time to time. However, in certain cases, the whole process of updating information is uncertain, ambiguous and erroneous in terms of intellectual properties and policies for data exchange. Any wrong information is risky and should be minimised by various strategies such as correspondence protocol'

iv. *Intellectual property (IP):* Intellectual property (IP) is also the concern in a BIM project. In Malaysia, the law is governed by the Intellectual Property Corporation of Malaysia Act 2002. A copyright is the key form of IP in the construction industry. One of the common examples of copyrights is to protect a consultant's design drawings. For a non-BIM project, the main focus is on copyrights. The grant of a license is sufficient for a non-BIM project as each consultant's design is separate, making it easy to identify who owns the copyrights in each element of the design. However, for a BIM project is not a simple exercise. This statement confirmed by Manager of VDC Development, Senior Lecturer and Assistant Director (G.1) that:

'The question of who owns the IP in the Model output will be the key point in our construction project today. As such, in my organisation, example of Model outputs such as cost data, facilities management data, energy efficiency, solar energy, orientation and others are the most important to the employer. Hence, employer should own the ownership of the entire model.

However, it is needed to be clear who owned the Model at the first place before the ownership of the IP rights is transfer to the employer. According to Currie, (2014), as the key benefit of BIM is the outputs that it will generate, and these outputs will be value to the employer, hence the ownership of the Model belongs to the employer. Therefore, all contributing parties of the Model must agree whether the employer requires ownership or simply a license. It must have free control to use the output as it requirements and manipulate the Model where necessary.

v. Government regulations: The government involvement is vital in implementation strategies of BIM in Malaysia. All respondents were discussed the same issue which seen the government is the pushing factor for BIM in Malaysia, as such by Quantity Surveyor and Senior Lecturer (G.1) revealed that:

'If Malaysia wants to implement BIM, the enforcement to be 'top-down' approach. To various consultant practices, enforcement should from the Government or else changes will not been realised. Previously, they implemented BIM due to two basic reasons: 1) BIM is a 3D visualization and require a short time for the entire design which look attractive to owners. Nevertheless, upon implementation, they realised that, to date none of construction projects is successfully adopted BIM due to constraint of resources and lack of skill in BIM 2) It is also important to have a greater market demand from biggest property developers such as Sime Darby, PR1MA, ands Brunsfield Group for adopting BIM for their projects.

Based on Wong, Wong, & Nadeem, (2011), he proposes some BIM implementation steps that can be used by the government. The authors proposed six steps which are; policy and program, open standard development, design information evaluation, BIM implementation department, adoption by other departments and presentation, promotion and liaison. Firstly, government needs to specify the policy of adopting the BIM in new projects. Several programs must be held by the government to enhance the use of BIM in the industry. Secondly, is through the open standard development. The policy by government should encourage standard software applications for BIM. According to Wong et al., (2011), the vendors/developers effort need to be streamlined and the government is in a better position to instil synergy into various competing BIM software systems in the market. A third step is design information evaluation. The BIM policy should recommend that the design information be explicit and made available to partners so that the design intent can be easily understood and evaluated (Wong et al., 2011). BIM project participants must understand the design information to perform the efficient BIM implementation. Next step is to form a BIM implementation department. According to Wong et al., (2011), in order to implement the government's BIM policy, there should be one or two designated government departments/ or organisations to take up the major responsibilities for BIM implementation initially Building information modelling through some pilot projects. Others is adoption by other departments who seen the potential of BIM into the construction projects. A sixth step is by presentation, promotion or liaison by the government to the various industrial forums. Liaison with global professional bodies for information exchange and continuous improvements would be highly desirable (Wong et al., 2011).

vi. *Data translation/ interoperability*: There is rarely a single BIM Model on a complex project. The architect may have design model, structural engineer may have analysis model, contractor may have construction model, and fabricator may have shop drawing. It is supported by the statement from BIM Modeller and Manager of VDC Development (G.1) stating that:

'Many models used a different technology/software's which the information must be translated/fit into the standards such as IFC classes. As such, if this could happen, analysis and construction models could communicate, exchange data, and use the updated information.'

However, in certain cases the translator (IFC class) may not transfer all the information from the model to another model. IFC classes do not exist for all data types and may have data loss if the host application failed to model in the IFC class. The data translation failure caused model inconsistencies and errors as mentioned by Olatunji, (2016).

vii. *Data misuse:* As noted previously, Models can be created for several uses based on the work scopes. Difficulties may occur if one perfect model were used for different purposes that not meet its capabilities. According to Senior Executive, Senior Lecturer and BIM Modeller (G.2) highlighted that:
'As example; a structural analysis model may not synchronise with the architectural model as it is used for a different purpose than intended.'
The three difficult issues included currency, adequacy, and tolerance must be considered when information of one model is used for another model (Ashcraft, 2008).

3.3 Technical Success Measure

This section presents the results of technical aspect which include: intensive technical training; compatibility of hardware and software; compatibility of various standards-based (e.g., IFC products); data integrity/user authentication/data security and access control; privacy of external storage.

i. *Intensive technical training:* BIM software's require a high level of training; thus, it requires the acquisition of new sets of skills which ranging from understanding of the software's until interoperability applications. An effective training is critical to increase construction productivity. Some companies are willing to train their employees for in-house designers and some of it will hire external firms for training or outsourcing entire projects (Pena, 2011). The BIM Modeller, Manager, Senior Lecturer (G.1), Senior Lecturer and Assistant General Manager (G.2) defined that:
'In my organisation, the selected employees are required to undergo specific BIM training as per organisation's training plan and once completed they are allowed to apply the knowledge and skill using the BIM software'.
In most cases, BIM training will relate to a specific process or software system. Before any training takes place, a training strategy should be established. The training strategy should include: what subjects to train on; who needs what training; and what are the methods to achieve the necessary training. A training plan with clear objectives must be set up in order to meet the organisation's corporate demands. However, few respondents argued that the cost of training is expensive. Once the company has to fulfil the organisation's corporate demands, they still need an intensive BIM training. The potential of the skill from the training will developed as the projects grow.

ii. *Compatibility of hardware and software*: The hardware supplied should be in accordance with the recommended specification such as the RAM, CPU, hard drive and the video card storage (Coates, 2013). However, since RAM is now inexpensive, there is no reason for not using the BIM software's. The major hardware vendors such as HP, Dell, and Lenovo have a BIM software level category of desktop and workstations. The hardware should also consider the software vendor's performance in terms of data sources (32 or 64 bit needs). There are many more items of configuration necessary in order to ensure that the BIM software's operated to its maximum efficiency. It is supported by the statement from Manager of VDC Development, Senior Lecturer (G.1), Design Coordinator, Senior Lecturer and C&S Engineer (G.2) stating that:
'The cost of implementation could be high at the initial stage because it depends on your current infrastructure, hardware, and software. It is important to understand the hardware that you currently used and to compare on what it is needed (i.e., Revit Software).'

iii. *Compatibility of various standards-based* (e.g., IFC products): A standardised description through Industry Foundation Class (IFC, a standard data schema for exchanging data among different applications) and IFC/xml are common models that had developed by the International Alliance for Interoperability (AIA). In the architectural sector in particular, the major vendors gain support for import and export of IFC, including Graphisoft (Penttilä, 2006), Bentley (Mahdavi, 2004), and Autodesk.

iv.

v.

vi. Figure **2** shows the example of interoperability BIM software's between Revit and Tekla.

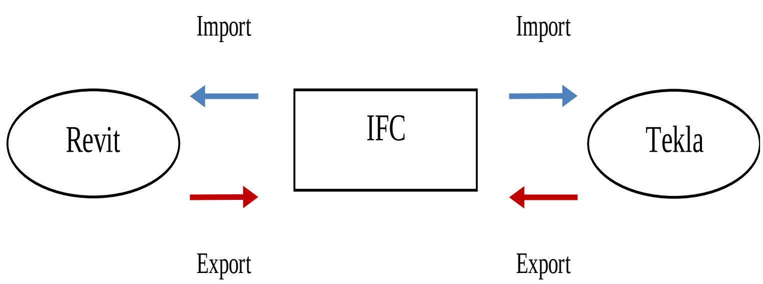

Figure 2 Example of interoperability between BIM software's

The IFC specifications are currently administered by the buildingSMART Alliance as Malaysia also starts to join since 2015 for open sharable asset information. As pointed out by C&S Engineer (G.1) defined that:

'Many of the primary BIM software packages are IFC compatible such as Autodesk Revit package, Tekla, and Bentley. These BIM tools currently used by industry support import and export IFC files.'

Under the AIA, all information in any compatible software program can be saved as .ifc file and can be opened and edited in another compatible software program. In addition, BIM software program is often designed to interrelate with other related software program such as energy or orientation analysis programs (Ashcraft, 2008). Conversely, it could incur some difficulties when the integration models were built separately in different software houses.

vii. *Data integrity/user authentication/data security and access control*: Data integrity/user authentication/data security and access control with other team members during the project lifecycle is essential on any typical construction project. If a party is hosting the information, ample steps to protect and secure the data must be taken to avoid data loss (Ashcraft, 2008). It is supported by the statement from Senior Assistant Director and BIM Manager (G.1) revealed that:

'Lack of support for data integrity, data security, access control and privacy data (i.e., cloud) could lead to a lack of data integrations among all project stakeholders.'

viii. *Privacy of external storage*: Construction data must be stored in a suitable place for archiving and reuse purpose. The methods currently used by construction team for storing and archiving data including paper, optical media, flash storage, network drive hosted by the company, portable external hard drive, cloud storage or on PCs/laptop. According to Eissa Alreshidi et al., (2016), the use of external storage raises many privacy issues such as the limited space of storage, and access rights to data is restricted and limited by company IT department. Nonetheless, data privacy of external storage is a big concern as highlighted by Quantity Surveyor (G.1), Senior Lecturer and Senior Executive (G.2):

'It not necessary to keep the data as private for the fact that all the work within a BIM/Revit model may share to public despite they will be a duplicating cases by others of our hard work'.

3.4 Financial Success Measure

This section presents the result of discussion for financial aspect of governing success measure in BIM-based projects. Some insights on financial aspect have been expounded by the participants incorporate: cost of initial hardware and software costs; training cost; maintenance costs (e.g. regular updates of software); ROI of projects; and costs for shared liabilities policy.

i. *Cost of initial hardware and software*: Currently, it is really costly to purchase BIM software's to most SME's company. To a certain extent, some companies tend to sub-let other BIM consultant to undertake the design and BIM model for the particular project as to fulfil the client needs. According to Consult Australia (Consult Australia, 2010), these costs are driven by nature of project, market forces and contract arrangement (e.g. warranties, maintenance and structured technical support). This is in line with the opinion of BIM Modeller, C&S Engineer (G.1), and Senior Lecturer (G.2) that:

'The cost of purchasing BIM softwares is too costly to our organisation. For the design component the range of prices are within RM20, 000.00 to RM30, 000.00, for structure applications and analysis, the prices range are within RM15, 000.00 to RM20, 000.00 per license excluding the training program package. Since the prices of the software's are too high, there are no initiatives for using BIM for the projects unless enforced by project client or government.'

This statement is contradicted by BIM Modeller and Senior Lecturer (G.2) indicated that:

'Cost of software and hardware are not a big constraint. Once the company has to fulfil the client requirements, they still need to buy BIM software. The benefits of BIM can be realised in the long-term for the company.'

ii. *Training cost:* The next important factor is the training program. All of the respondents agreed that training program for BIM as one of the success measure for BIM governance. According Ibrahim & Okeil, (2011), training should be provided to both designers and project managers who will oversee the process and review the drawings. According to Olatunji, (2011), organisations are different in structures, they will require different training package to manage BIM in line with varying business interests. Moreover, different categories of staff, (e.g. management, technical, support staff, etc.) will require different training in order to master their roles as BIM implementation trigger. This statement confirmed that training program could emerge as an important ways to develop BIM ideas to the players.

It is supported by the statement from Senior Assistant Director (G.1), Senior Lecturer and BIM Modeller (G.2) highlighted that:

Despite the BIM training is regarded as costly for the organisations, this could be overcome when the organisations able to organise an in-house training program to reduce the high cost and the training should be specifically designed to fit the needs of the them'.

According to Consult Australia, (2010), employers may reduce training costs by recruiting new graduates with appropriate skills and experience as staff members to drive BIM initiatives. Therefore, by introducing BIM applications to the new graduates in Universities, it is believed that, it will reduce the cost of training for BIM for the organisations in future.

iii. *Maintenance costs* (e.g. regular updates of software): The project lifecycle is parallel to the development of the new technologies (hardware and software). Construction players who intend to use the BIM for their projects should well versed, in the current updated software. According to BIM Manager, Senior Lecturer and Manager of VDC Development (G.1):

'The biggest challenge to maintain with BIM software's such as Revit Autodesk package is the cost factor. BIM software is probably one of the most expensive software's to purchase even though the benefits are at large.'

In addition, the less exposure to BIM contributed to lack adoption of it. As such, there is a need to strategise ways to increase the level of understanding in BIM. According to Robson & Littlemore, (2011), it was reported that the same programme and versions of programmes are important for interoperability. This is highlighted by Manager (G.2) that:

'One of the biggest disadvantages of BIM is not compatibility, as in my organisation, at the moment we are working on one project where we have to use the 2014 version because the other consultants haven't up graded to 2015.'

iv. ROI of projects: According to McGraw-Hill Construction, (2009), majority of users (architect, engineer, contractor and owner) reports revealed a positive returns on their investment in BIM. It is reported that 63% of BIM users perceived a positive ROI on their overall investment in BIM, whereas about 87% of BIM expert users perceive the positive ROI compared to 38% of BIM beginners. These statements confirmed by Quantity Surveyor (G.1), Senior Lecturer and Design Coordinator (G.2) indicated that:

'The economic value of BIM technology is always being measured through ROI. The sooner the project is operating; the sooner the revenue starts.'

Construction players today understand the correlation between uses of BIM with the return on investment achievement during the projects and indirectly improve the project delivery.

v. *Costs for shared liabilities policy*: Based on Ghaffarianhoseini et al., (2016), a conceptual building model could help project clients/developers with a cost information provided to determine the desired requirements with a given cost and time. However, conceptual building model needs participation from project teams (consultants) that shared the same liabilities based on the scope of works. A strategised liabilities policy of every team members should be determined at early stage to avoid the cost hitches. It is supported by the statement from Manager, Senior Lecturer and Senior Executive (G.2) stating that:

'Owners may think the model is entitled to them; however, the right of others such as architect, design engineer (s), design special equipments and others also need to be protected as well. Thus, additional costs of the shared liabilities must be clarified prior the project is going to start.'

4. Conclusion

In conclusion, this paper attempts to investigate governing success measure of BIM-based projects with regards to the BIM success factors. Four vital findings are: socio-organisational; legal; technical and financial to gauge positive impacts implementation. The findings revealed a number of sources that can be the reason to the success of BIM implementation.

Subsequently, the workshop derived at four factors of success measures that have been divided into socio-organisational, legal, technical, and financial. It was agreed that well-organised defined of roles and responsibilities and changes of team members for BIM-based projects are important elements to resource in socio-organisational success measure factors.

When adopting BIM in collaborative environment, collaboration standards related to legal success measure such as liability of wrong information can appear as there is no fair practice for electronic information and documentation in BIM projects practices.

More importantly it is a major concern on the need for intensive technical BIM training tackled the problem of data integrity, data security, and data storage among stakeholders across the lifecycle.

Hence, despite there are many vendors' offers an intensive BIM training, the financial factor is the utmost priorities success measure for BIM development (i.e., cost of initial hardware and software tools and cost of training in BIM).

It is anticipated that the findings reported in this paper could provide an insight for future strategies and guidelines for the development of BIM projects in Malaysia. BIM governance framework proves to be valuable for project stakeholders in managing collective efforts to standardise construction processes.

The research presented in this paper is part of an ongoing Ph.D. research study at the Faculty of Architecture, Planning, and Surveying, UiTM Malaysia to develop a framework of client governance in BIM for construction projects in Malaysia. The result of the study will important for future strategies and guidelines for the development of BIM projects in Malaysia.

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