The Framework of Building Information Modeling (BIM) Implementation Stages for Malaysian Construction Industry

Nur Soleha Abdul Rahim[1], Sharifah Akmam Syed Zakaria [2]

[1] *Doctorate Student, School of Civil Engineering, Universiti Sains Malaysia, Penang, Malaysia*

[2] *Lecturer, School of Civil Engineering, Universiti Sains Malaysia, Penang, Malaysia*

***Abstract*— Building Information Modeling (BIM) has attracted ever increasing attentions from construction industry stakeholders around the world including Malaysia. Numerous studies have been conducted in exploring the benefits of BIM and proposing strategies for BIM implementation. However, to convince the industry stakeholders to implement BIM technology is relatively challenging. Tangible evidences are needed to bring up the industry's acceptability towards the technology. In Malaysia, the Construction Industry Transformation Programme (CITP) has been developed to drive the transformation and development of the construction industry. One of the cases highlighted in the CITP is on the limited adoption of information technology such as BIM. Therefore, currently the Malaysian government is actively engaging with construction industry stakeholders to encourage the BIM implementation. This paper aims to propose a framework of BIM implementation stages in the construction industry of Malaysia. Three case studies have been analysed as a fundamental study to develop the framework. The results show that two of the companies are at the adaptation stage and one of the companies is at the application stage. At this point of time, the results indicate that the companies are more comfortable to experience only some part of the BIM benefits compared to fully utilise the technology. Fundamentally, the companies will only be at the adoption stage once the confidence level towards the technology is increasing and the companies will be categorised in the application stage when the companies are able to perform knowledge transfer related to BIM technology. This implementation stages can be used as an indicator to predict the direction of BIM in Malaysia. Thus, to ensure the successfulness of BIM implementation, there is a need to understand the current stages of company's BIM implementation and propose the criteria needed for a company to move from one BIM stage to another.**

Keywords—Building Information Modeling, Implementation Stages, Malaysian Construction Industry

I. INTRODUCTION

The construction industry is always been associated with the issues related to cost overrun [1], delay [2] and massive waste production [3]. These issues occurred due to the lack of communication and often changes of project design during the construction phase. Over the last few decades, information technology (IT) plays an important role in enhancing communication and efficiency of the construction process [4]. Currently, majority of the construction industry players are using IT tools such as 2D AutoCAD to enhance the performance of its delivered products and most of the players are already exposed to 3D modeling. However, recently, the latest ICT tool, Building Information Modeling (BIM) has been introduced to the Malaysian construction industry to reduce construction cost and avoid design problems. By adopting this kind of technology, waste production from construction can be minimised at the design and construction stages as well as throughout the lifecycle of the project [5]. BIM attracted a considerable amount of attention from construction industry stakeholders around the world due to its compromising benefits, yet the implementation is still slow. Since then, numerous studies have been conducted in exploring the benefits of BIM and proposing strategies for BIM implementation.

The Ministry of Works Malaysia (MoW), in collaboration with the Construction Industry Development Board Malaysia (CIDB) has produced the five-year plan (2016-2020) for the construction industry called Construction Industry Transformation Programme (CITP). CITP was developed through the discussion with a wide range of construction stakeholders to gather inputs and support [6]. In September 2015, the Prime Minister of Malaysia has launched the CITP to drive the transformation and continue the development of Malaysia's construction industry [7]. In CITP, BIM has been highlighted in one of the case to change under the productivity thrust. Thus, it shows that the Government is taking serious on the development and implementation of BIM. In order to fully understand the industry's acceptability towards the technology, a proper framework is needed to explore and monitor the company's level of BIM implementation.

1.1 Building Information Modeling (BIM) Studies in Malaysia

BIM is one of the newer technologies that brings a lot of benefits to the construction industry and been predicted to be a main pillar of the construction industry in future. Numerous versions of BIM definitions exist in the previous research when BIM started to received attentions from construction industry stakeholders. According to National BIM steering committee, *"BIM is a modeling technology with associated set of tools and processes to produce, communicate, analyse and use of*

digital information throughout the construction life-cycle" [8].

In Malaysia, the Government has started to introduce BIM technology in 2007. Since then, various researches have been conducted related to BIM. Tabulated in Table 1.0, it shows several researches related to BIM in Malaysia from year 2013 to 2016. Mostly, the researchers tend to focus on barriers or challenges faced by the Malaysian construction related companies to implement BIM. Unawareness of the technology, lack of knowledge about BIM, high initial cost of software and hardware, lack of demand from client and BIM is not one of the requirement needed from other team members was identified as the barriers to implement BIM. However, a focus-group discussion was conducted by Salleh and Phui Fung [9] indicates that cost of implementation is not a critical barriers, but, lack of expertise, training and awareness is more critical in that respect.

Furthermore, some of the researchers also proposing a framework or model related to BIM. Haron [10] have proposed a framework for the BIM organisational readiness by considering the main element of technology innovation (process, management, people and technology) and Enegbuma, et al. [11] have proposed a BIM adoption model in Malaysia. However, there is a lack of study related to BIM implementation stages in Malaysia. Therefore, this study will focus on proposing a framework showing the process of BIM implementation in Malaysia.

1.2 Stage Models of Organizational Innovation

There are several studies have been conducted to proposed the stage models (SM) of organisational innovations since 1960. The purpose of SM research is to explain on the sequence of activities occur during the implementation of innovation either for individuals, firms, industries or countries [12]. Researchers are tends to proposed and explained on the process of IT innovations for decision-making process. The idea of decision-making process was initiated by Rogers (1962) through the framework of five-stage model of innovation process. Later, Ettlie [13] proposed a framework with the slight modification of Rogers (1962) original five-stage model. The comparison among the innovation models are shown in Figure 1.

Ettlie [13] performed an investigation on the implementation of service innovations in the transportation industry. Additionally, Cooper and Zmud (2001) used the proposed research model to interpret the results of a common manufacturing IT application. Each technology would have some variations in development activities even among the developing countries. Rogers (2003) proposed a model to explain on the process that an individual or other decision maker have to undergo before confirming the decision made to implement new technology.

As described in the above section, a number of research related to BIM in Malaysia have been conducted by researchers in order to provide the best information to the industry. However, the studies focusing on frameworks or models development related to BIM for Malaysian construction industry context is still lacking. Therefore, based on the previous research, a four-stage framework for BIM implementation in Malaysia is proposed to identify each of the activities occur during the innovation.

Figure 1 shows the proposed framework for BIM implementation in Malaysia. Ettlie [13] was selected as a foundation to develop BIM implementation stages. For BIM context, these four stages are needed to measure the current company's level of BIM implementation. In Malaysia, BIM technology is still at nascent stage where the development is low and stagnant [14, 15]. Therefore, application stage is proposed to determine the percentage of companies that are able to share their knowledge and become one of the "champions" to lead the innovation. The process consists of four stages: (1) *Awareness*, the innovation exists but complete information is not yet available or has not been obtained; (2) *Adaptation*, the innovation is presently being used on a limited basis in order to determine its utility in a full-scale of implementation; (3) *Adoption*, the innovation has been adopted and now is being implemented on a full-scale basis; (4) *Application*, the innovation is being transferred to other parties with the same interest of using the technology.

II. METHOD

A questionnaire survey was distributed to the construction related companies that have implemented BIM in at least one project. Table 2.0 shows the background of the respondents. The company's information is presented in Table 3.0. The questions were designed based on three different Likert's scale of five (5) ordinal measures, Never to Always, Definitely no to Definitely yes and Not at all to Extremely well. Some of the questions are using yes or no options. The respondents were required to provide information according to their current practices on BIM. For the analyses, the answers for each of the question were categories based on the proposed BIM implementation stages. The questions were analysed one-by-one based on the available options provided. For example, Q1 – How often does your company implement BIM in any of your projects? Table 4.0 shows the approach used to evaluate Q1.

Usually, it is difficult to differentiate between adaptation and adoption process. Therefore, most of the questions are designed to be more focus on adaptation and adoption stages. The overall marks for each of the questions are summarised to determine at which stage the companies are currently placed. The example of summarised results is presented in Table 5.0. Throughout the analysis, when the result shows that the company is currently at the adoption stage, the last criteria will be considered to determine either the company are ready to

be at the application stage or maintained at the adoption stage. If the company fulfilled the criteria, the company will be placed at the application stage even though the highest marks indicate that the company is in the adoption stage.

III. RESULTS AND DISCUSSION

One of the factors identified as a barrier to BIM implementation is lack of awareness and knowledge on BIM. In order to raise the awareness level among industry players, many workshops/seminars and training have been organised by various bodies (CIDB, Public Work Department, Royal Institute Surveyors Malaysia) addressing on BIM [11, 16] in Malaysia.

Table 6.0 shows the level of respondent's awareness towards BIM technology. Respondent from C1, C2 and C3 have experience in handling BIM software for at least less than 12 months. For the overall case studies, C1 and C2 are currently at the adaptation stage and C3 is already at the application stage as indicated in Table 7.0. In this study, discussions are based on three (3) major discussions, namely BIM technology usage, BIM operating environment and BIM Organizational Culture.

3.1 BIM Technology Usage

Normally when implementing new technology such as BIM, a company need to go through an adaptation process where they only implement BIM for certain projects or by utilising some of the benefits offered by that technology. This process would help the company in planning the suitable time to move from the adaptation stage to the adoption stage after gaining sufficient knowledge and confidence [17]. Therefore, it is not suitable for a company to adopt the technology directly as because the cost and learning curves would be too high.

Respondent from C1 indicated that their company rarely implementing BIM in any of their projects. However, response received from respondent C2 and C3 indicates that their company only implement BIM accordingly in their projects. This shows that these companies are currently in the process of learning new technology to gain more knowledge and experience before deciding to adopt the technology. A case study conducted by Zakaria, et al. [18] shows that a SME company have performed a joint venture (JV) with external party to form a BIM expert group. The idea to form a JV could be one of the strategies to become more familiar with the technology and improve their skill before deciding to fully operate the technology fully on their own.

Furthermore, respondents from C1 and C2 shared that their company are currently at level 1 of BIM maturity level where the process involves a collaboration tool with a common data environment to manage 2D or 3D formats with standard data structures. This shows that the companies are trying to increase their level of confidence and understand the technology in a silo way without any digital collaboration with other parties. However, C3 indicated that their company is currently at level 2 of BIM maturity level. Level 2 is more on the production of 3D models with attached information in separate BIM tools and the integration based on proprietary interfaces. This shows that the company C3 is already at the adoption stage where they are ready for digital collaboration with other parties.

According to the explanation in the maturity level, 4D and 5D cost elements are usually performed when the companies are at level 2 of BIM maturity level. Company C1 never perform cost estimation using BIM, C2 rarely and C3 sometimes. Therefore, C1 is placed at the adaptation stage, whilst C2 and C3 at the adoption stage. However, company C1, C2 and C3 are rarely using BIM for project's schedule projection. All of the respondents are classified at the adoption stage due to their experience in performing 4D analysis.

Other than that, respondent C1 indicates that their company is rarely implementing BIM fully own their own; however, C2 and C3 choose sometimes to fill-up the answer. This shows that all of the companies are at the adaptation stage as they need assistance from others to fully implementing BIM. However, all of the respondents had never outsourced their projects to BIM consultants.

3.2 Operating Environment

Good operating team plays an important role in enhancing people passion towards learning new knowledge and sharing information. According to response received from respondent C1 and C2, there is no BIM division to handle projects using BIM in their company. There are several issues that need to be considered before developing a proper BIM team especially the financial condition. Therefore, these companies are considered at the adaptation stage. Contrast response received from C3 where the respondent indicates that their company have BIM division to handle projects using BIM. The respond received from C3 has positioned the company at the adoption stage.

In order to understand further on the company interest towards BIM, respondent from company C1 mentioned that they do not have any plan to develop BIM team to handle projects using BIM and company C2 is still uncertain. This shows that both company C1 and C2 are comfortable to be at the adaptation stage compared to C3. As mentioned earlier, one of the barriers to implement BIM is the upfront investment cost to purchase the hardware, software and sending their staff for training, therefore, the company have to be well prepared before implementing BIM technology.

3.3 Organizational Culture

According to response received from the respondents, company C1 and C2 are uncertain with the plan to implement BIM in the near future. However, company

C3 has provided a positive response towards their plan to implement BIM. Therefore, company C1 and C2 are considered at the adaptation stage and C3 at the adoption stage. All of the respondents also stated that they have been using BIM for more than one construction phases. These indicate that all of the respondents can be placed at the adoption stage.

A question was asked related to the ability of the company to assist any other company to implement BIM. This is one of the attributes to determine either the company remain at the adoption stage or can be placed at the application stage. As mentioned in previous section, Malaysian Government is looking seriously into transforming the construction industry by year 2020 with one of the cases to change is related to BIM. Therefore, BIM champion is needed to drive the transformation. This attribute is to measure the percentage of companies that are able to perform knowledge transfer or assist other companies to implement BIM. The results received from the respondents mentioned that only company C3 are able to do so. Company C1 and C2 are still lack of ability to assist other companies. Therefore, the company will only be placed at the application stage when they are able to perform the mentioned action. The summary of the results are shown in Table 8.0.

IV. CONCLUSION

In order to implement new technology such as BIM, a full consideration from all aspects need to be done. The willingness of people to implement new technology is more important than other technical or non-technical factors [17]. However, the company that attempt to implement BIM have to go through the implementation stages one-by-one in order to increase people confidence towards the technology and to avoid failure. Based on the results obtained from this study, currently the companies are still in the process of knowing the technology before deciding to the next stage of implementation. The full analysis will be conducted to measure the percentage of companies at each of the implementation stages and the results could be used as a guideline to prepare a proper strategic plan for the industry in order to achieve CITP aims by year 2020.

V. ACKNOWLEDGEMENT

Many thanks for the contributions provided during the data collection process.

VI. REFERENCES

[1] I. Abdul Rahman, A. H. Memon, A. Karim, and A. Tarmizi, "Significant factors causing cost overruns in large construction projects in Malaysia," *Journal of Applied Science,* vol. 13, pp. 286-293, 2013.

[2] A. H. Memon, I. A. Rahman, M. Akram, and N. M. Ali, "Significant factors causing time overrun in construction projects of Peninsular Malaysia," *Modern Applied Science,* vol. 8, p. 16, 2014.

[3] K. A. M. Kamar and Z. A. Hamid, "Sustainable construction and green building: the case of Malaysia," *WIT Transactions on Ecology and The Environment,* vol. 167, 2012.

[4] Y. Lu, Y. Li, M. Skibniewski, Z. Wu, R. Wang, and Y. Le, "Information and communication technology applications in architecture, engineering, and construction organizations: A 15-year review," *Journal of Management in Engineering,* vol. 31, p. A4014010, 2014.

[5] Z. Liu, M. Osmani, P. Demian, and A. N. Baldwin, "The potential use of BIM to aid construction waste minimalisation," 2011.

[6] CIDB, *Construction Industry Transformation Programme 2016-2020*, 2015.

[7] T. K. L. Tamboo. (2015, 7 March 2016). *CITP to transform the construction industry before 2020*.

[8] CIDB, "Building Information Modeling Roadmap for Malaysia's Construction Industry," 2013.

[9] H. Salleh and W. Phui Fung, "Building Information Modelling application: focus-group discussion," *Građevinar,* vol. 66, pp. 705-714, 2014.

[10] A. T. Haron, "Organisational Readiness to Implement Building Information Modeling: A Framework for Design Consultants in Malaysia," Doctor of Philosophy, School of the Built Environment, University of Salford Manchaster, United Kingdom, 2013.

[11] W. I. Enegbuma, U. G. Aliagha, and K. N. Ali, "Preliminary building information modelling adoption model in Malaysia: A strategic information technology perspective," *Emerald Insight,* vol. 14, pp. 408-432, 2014.

[12] R. A. Wolfe, "Organizational Innovation: Review, Critique and Suggested Research Directions*," *Journal of Management Studies,* 3 May 1994 1994.

[13] J. E. Ettlie, "Adequacy of stage models for decisions on adoption of innovation," *Psychological Reports,* vol. 46, pp. 991-995, 1980.

[14] A. H. Memon, I. H. Rahman, I. Memon, and N. I. A. Azman, "BIM in Malaysian Construction Industry: Status, Advantages, Barriers and Strategies to Enhance the Implementation Level," *Research Journal of Applied Sciences, Engineering and Technology,* vol. 8, pp. 606-614, 2014.

[15] A. A. Latiffi, S. Mohd, N. Kasim, and M. S. Fathi, "Building Information Modeling (BIM) Application in Malaysian Construction Industry," *International Journal of Construction Engineering and Management,* vol. 2, pp. 1-6, 2013.

[16] A. N. Harun, S. A. Samad, M. N. M. Nawi, and N. A. Haron, "Existing Practices of Building Information Modeling (BIM) Implementation in the Public Sector," *International Journal of Supply Chain Management,* vol. 5, pp. 166-177, 2016.

[17] J. Won, G. Lee, C. Dossick, and J. Messner, "Where to Focus for Successful Adoption of Building Information Modeling within Organization," *Journal of Construction Engineering and Management,* vol. 139, 2013.

[18] Z. Zakaria, N. M. Ali, A. T. Haron, A. Marshall-Ponting, and Z. A. Hamid, "Exploring the adoption of Building Information Modelling (BIM) in the Malaysian construction industry: A qualitative approach.," *International Journal of Research in Engineering and Technology,* vol. 2, pp. 384-395, 2013.

[19] Z. Zakaria, M. A. Nasly, T. H. Ahmad, A. Marshall-Ponting, and A. H. Zuhairi, "Exploring the Barriers and Driving Factors in Implementing Building Information Modelling (BIM) in the Malaysian Construction Industry: A Preliminary Study," *Journal Institution of Engineers Malaysia,* 2013.

[20] S. Gardezi, S. Shujaa, N. Shafiq, M. F. Nurudinn, S. A. Farhan, and U. A. Umar, "Challenges for Implementation of Building Information Modeling (BIM) in Malaysian Construction Industry," *Applied Mechanics & Materials,* 2014.

[21] S. Mamter and A. R. Abdul Aziz, "Holistic BIM Adoption and Diffusion in Malaysia," *MATEC Web Conf.,* vol. 66, p. 00094, 2016.

Table 1. Studies related to Building Information Modeling (BIM) in Malaysia

Author	Year	Benefits	Barriers/ Challenges	Driving Factors	Strategies	Model/ Framework	Others:
Zakaria et al.	2013						√
Zakaria et al.	2013		√	√			
Haron	2013					√	
Memon et al.	2014	√	√		√		
Gardezi et al.	2014		√				
Salleh and Phui Fung	2014		√		√		
Enegbuma et al.	2014					√	
Mamter and Abdul Aziz	2016						√

Table 2. Respondents Information

Factors	C1	C2	C3
Gender	Female	Female	Female
Position	Engineer	Engineer	Engineer
Year of working experience	<5 years	<5 years	<5 years
Education level	Master's Degree	Bachelor Degree	Bachelor Degree

Table 3. Companies Information

Factors	C1	C2	C3
Expertise	Consultant	Consultant	Contractor
Number of employees	50 – 150	<50	>500

Table 4. Q1 evaluation

Options:	CX	CY	CZ	Stage:
Never				Awareness
Rarely	1			Adaptation
Sometimes		1		Adaptation
Most of the time				Adoption
Always			1	Adoption

Table 5. Example of Results Summary

Stage:	CX	CY	CZ
Awareness	1	1	1
Adaptation	5	3	1
Adoption	2	4	6
Application	-	1	-
Summary	Adaptation	Application	Adoption

Table 6. Respondents Awareness on BIM

Factors	C1	C2	C3
BIM Knowledge	Slightly well	Moderately well	Slightly well
BIM Experience	<12 months	1 – 5 years	<12 months
BIM software	Autodesk Revit	Autodesk Revit	Autodesk Revit

Table 7. BIM Implementation Stages

Stage:	C1	C2	C3
Awareness	1	1	1
Adaptation	8	6	2
Adoption	2	4	7
Application	-	-	1
Summary	Adaptation	Adaptation	Application

Table 8. Summary of Overall Results

Factors	C1	C2	C3
Implementing BIM in any projects	Rarely	Sometimes	Sometimes
BIM maturity level	Level 1	Level 1	Level 2
BIM division in handling BIM projects	No	No	Yes
Plan to develop a proper BIM division	No	Uncertain	-
Fully implement BIM on its own	Rarely	Sometimes	Sometimes
Outsource projects to BIM consultant	Never	Never	Never
Phase of construction using BIM	-	>1 phase	>1 phase
Use BIM for project's cost estimation	Never	Rarely	Sometimes
Use BIM for project's schedule projection	Rarely	Rarely	Rarely
Plan to implement BIM in the near future	Uncertain	Uncertain	Definitely Yes
Assist any other companies on BIM	No	No	Yes
BIM Implementation Stage	Adaptation	Adaptation	Application

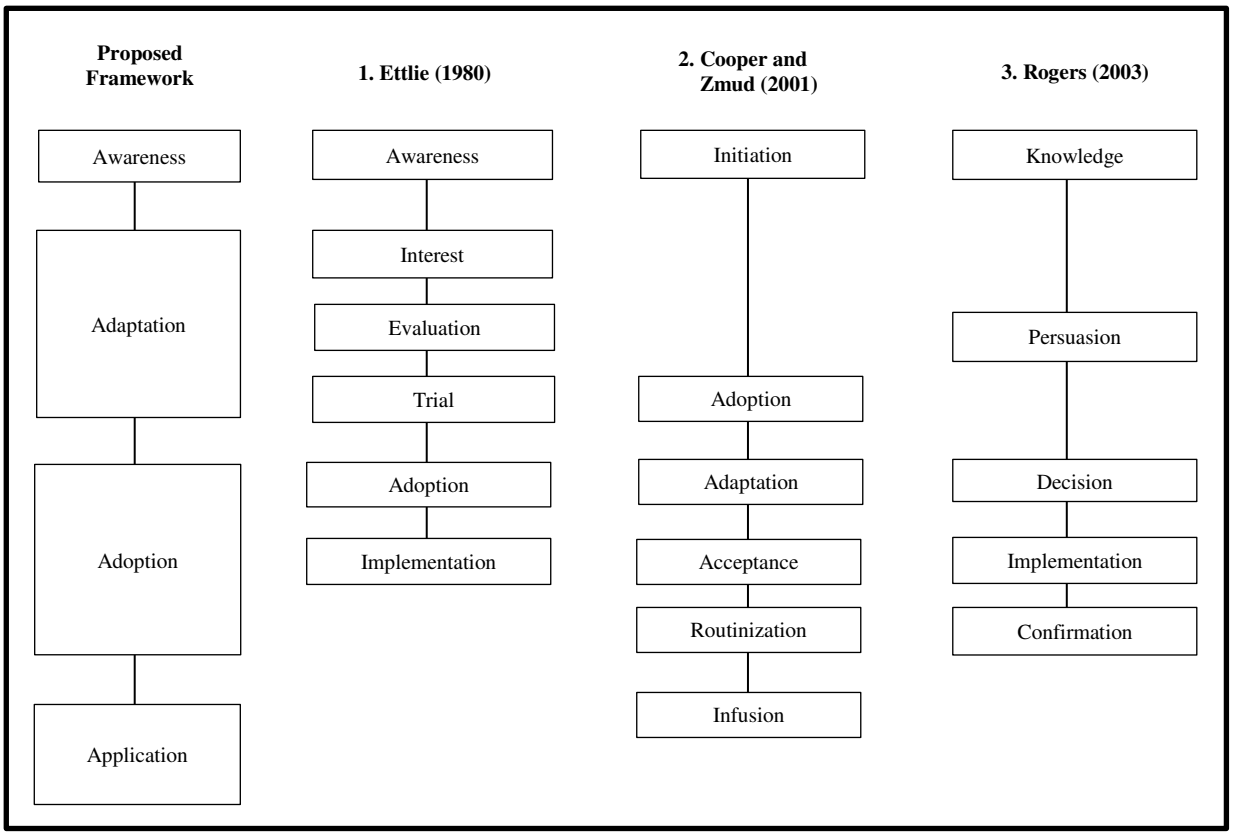

Figure 1. A Proposed Framework and Comparison of Innovation Models