Development, Planning & Management

Developing a Technology Implementation Framework from the Perspective of Sustainability

Sharifah Akmam Syed Zakaria & Nur Soleha Abdul Rahim
School of Civil Engineering, Universiti Sains Malaysia, Malaysia
Email of corresponding author: akmam@usm.my

Abstract

Consideration of sustainability elements during the decision-making process in a construction project requires knowledge and awareness on the issues affecting environmental, social and economic aspect. Malaysia's construction agencies have highlighted the important of environmental sustainability in the Construction Industry Transformation Programme (CITP) as a guideline in achieving a more sustainable construction. Every year, gigantic amount of solid wastes are generated from construction industry which create multiple environmental issues and causing pressure to the disposal sites. Implementation of information technology such as building information modelling (BIM) is considered as one of the alternatives in resolving the construction issues. The capability of BIM in predicting potential waste generation, avoid increases in project's cost and producing a better quality of end products indirectly contributing to the improvement of construction industry's image. However, there is still lack of BIM implementation among construction players in Malaysia. As the first step in exploring technology implementation in the construction industry, the development of proper framework is needed to identify the potential numbers of companies having the capability to drive the implementation. In order to validate the proposed technology implementation framework, an analysis related to student's sustainable daily-life activities was conducted. A total number of 155 students from a local university in Malaysia were involved in the survey. The results indicate that currently students are still requiring information to increase awareness on the daily-life activities that can contribute to sustainability. In academic institutions, practicing sustainable life would increase student's awareness on the impact of simple daily-life activity towards the physical environment of the planet. This attitude should be maintained by each student and the sustainable life shall be practiced continuously particularly when the students are venturing into the real working environment. Thereby, young engineers will appreciate the nature further and develop a more sustainable development for future generations.

Keywords: Malaysia; Construction Industry; Building Information Modeling; Sustainability; Academic Institutions

1. Introduction

The construction industry can be described as one of the most challenging industries in various countries around the world including Malaysia. Cost and time overrun are the most common issues associated with construction industry. In Qatar, the public projects facing the same issues where the constructed projects between years 2000 to 2013 experiencing 54% cost overrun and 72% time delay (Senouci et al., 2016). Mostly the construction projects in Malaysia also experiencing cost overruns (Shehu et al., 2014). Poor planning and site management, lack of contractor's experience, high level of project's complexity and delay in payment are some of the factors contributing to cost overrun and project delay (Shah, 2016).

Additionally, massive waste production created by construction industry also becoming as one of the major issues highlighted by numerous researchers. Every year, gigantic amount of solid wastes are generated from construction industry which create multiple environmental issues and causing pressure to the disposal sites. This is due to the lack of communication, often changes of project design (Bekr, 2014, Nagapan, 2011) and mistakes during construction (Ikau et al., 2016, Nagapan, 2011). In Malaysia, the Government has highlighted on the issue regarding high volume of construction and demolition waste under one of the main thrusts in the Construction Industry Transformation Programme (CITP) (CIDB, 2015). This indicates that the Government is committed in overcoming the issues pertaining to the construction waste generation in Malaysia.

Implementation of information technology such as building information modelling (BIM) are foresee as one of the alternatives in resolving the construction issues. However, despite positive records on BIM technology implementation from other countries, the construction industry practitioners in Malaysia are still considering changing from current practices to BIM technology and causing the implementation rate of BIM around 10% in 2013 (CIDB, 2015). This issue is particularly happened due to the lack of BIM-ready workers (Ahmad Latiffi et al., 2015), high upfront investment cost (Ahmad Latiffi et al., 2015, CREAM, 2014), lack of awareness (Memon et al., 2014, CREAM, 2014) and reluctant to change (CREAM, 2014). Thus, proper planning on BIM implementation stages is needed to encourage the Malaysian construction players to implement BIM technology.

2. Building Information Modeling (BIM) Implementation Stages

Implementation of BIM technology has allowed the construction industry to achieve remarkable gains especially in terms of productivity, efficiency and construction work quality. BIM is currently growing and expected to continue in the coming years. In the North America, the implementation of BIM expanded from 28% in 2007 to 71% in 2012 (McGraw-Hill Construction, 2014). A similar dramatic expansion in the United Kingdom (UK) with the current rate of implementation is 62% (2017) compared to 13% in 2011 (Malleson, 2017). Besides the successful implementation, some of the countries are still experiencing slow up-take of BIM technology. The implementation of BIM in Malaysia is considered at the nascent stage where the development is slow and stagnant (Memon et al., 2014). This scenario prevents the real benefits of BIM be utilised by all construction industry practitioners in Malaysia.

The slow uptake of BIM technology among construction practitioners, the concern towards high-investment costs and lack of BIM-ready engineers has urge the needs to develop a proper framework on series of stages for BIM implementation process in Malaysia. This framework is to assist the construction industry practitioners in implementing BIM according to the stages and determine the current trend of BIM implementation in Malaysian construction industry. Ettlie (1980) model was selected as a guideline to develop BIM implementation stages based on Malaysian scenario. Four (4) stages were proposed in the sequence of awareness, adaptation, adoption and application as shown in Figure 1.

The criteria for each of the stages are based on the following definition: (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.

Figure 1: Proposed BIM Implementation Stages Framework

In order to verify the sequence of the proposed technology implementation framework, an analysis on the process that indicates the possibility of having a similar sequence of stages need to be conducted. In this case, implementation of sustainable lifestyle among students was identified as the most relevant study to be used in the verification process. Thus, the aim of this study is to verify the proposed framework and understand the sequence of stages for student's to implement a sustainable lifestyle.

3. Methodology

The study was conducted at one of the local university in Malaysia involving the total number of 155 students. A questionnaire survey was distributed to the students and Table 1 presents the general information of the respondents. The questions were designed based on Likert's scale of five (5) ordinal measures from never to always. The respondents were required to provide information on their daily-life activities.

Table 1: Respondent's Information

Gender		**Age**		**Race**			**Current Residence**	
Male	Female	< 23	> 23	Malay	Chinese	Indian	Hostel	Off-campus
95	60	77	72	51	82	22	144	11

In order to analyse the data, the questions was divided into four (4) main stages according to the proposed BIM technology implementation framework and were analysed using index average or relative importance index formula to establish the ranking for each of the stages.

$$\text{Index average} = \frac{\sum ai \, X \, xi}{\sum xi}$$

where :
ai constant (weighing factor)
xi variables representing respondents frequency of response

4. Results and Discussion

A simple daily-life activity may contribute to the saving of physical environment of our planet. In this context, information and communication technology (ICT) play an important role in disseminating and providing information on sustainability to their user. Based on the results, students are more prefer to gain information related to sustainability from the social media, websites and blogs. Thus, leverage on ICT to share information would increase the possibility for the students to be more aware on sustainability.

Table 2: Sources of Information

Sources of Information	**Total**
Social media	95
Websites	87
Blogs	66
Online workshops/classes	48
Newspapers	45

4.1 Awareness

In order for students to understand the real meaning of sustainability, the students should be exposed to the sustainable environment in their daily life. Most of the students agree that sustainability influencing their decision in choosing which university to attend and where to live as shown in Figure 2 and 3. These figures show that students are aware of sustainability, nevertheless, with limited information and knowledge.

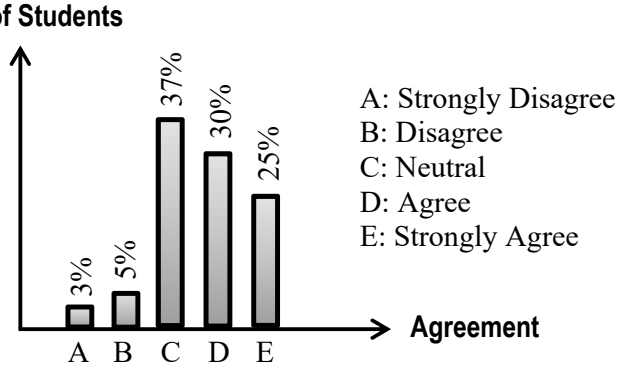

Figure 2: Sustainability influencing the decision in choosing college/university to attend

In the survey, five (5) environmental friendly actions have been identified as the factors that can contribute to the increment of student's awareness towards sustainability. Based on the results, majority of the students stated that they never or only sometimes doing the listed actions under the awareness stage as tabulated in Table 3. The results indicate that currently students are still requiring information to increase their awareness on the daily-life activities that can contribute to the environmental sustainability. Thus, university should organise more programme or events to educate students on sustainability and improve the facilities around campus such as providing/increasing recycle bin or develop sustainable park.

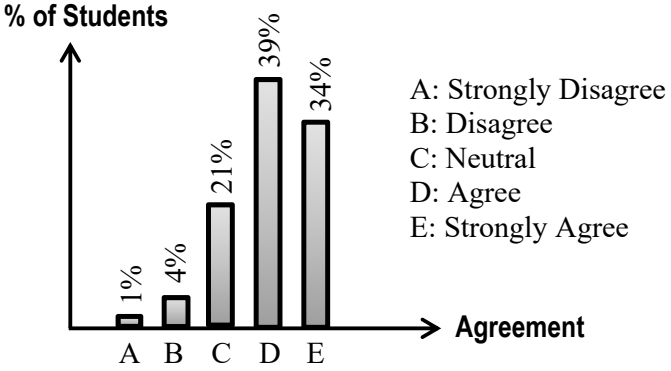

Figure 3: Sustainability influencing the decision in choosing place to live

Table 3: Activities for Awareness Stage

Sustainability Behaviour	Never to Sometimes	Often to Always	Mean	Total Mean
Think about sustainability issues	88	67	3.41	3.10
Attend programme/event related to sustainability	106	49	3.15	
Attend lectures focused on sustainability	109	46	3.03	
Take classes on sustainability subjects	112	43	2.94	
Perform research on a sustainability topic	105	50	2.95	

4.2 Adaptation

Once the students are aware on the activities that can contribute to the environmental sustainability, changing their current practices would conserve the physical environment of our planet. The students may realise on the factors affecting environmental sustainability but only limited to the certain activities. Adaptation stage listed the activities involves in changing our daily-life activities into a more sustainable way without or with less involvement of cost.

In the adaptation stage (Table 4), nine (9) activities have been identified and the results indicate that the majority of students are practicing six (6) out of nine (9) sustainable behaviours in their daily activities. Refill water bottles, turn of lights when not in use, using backside of printed paper for taking notes, exercise in sustainable way and bike/walk to campus/classes are the activities that often or always been implemented by the students. The students should also be encouraged to use recycle bag when going out for shopping, recycle, take short showers and donate unwanted belonging to the needed ones to reduce the impact on each of the activities towards the environment. Thus, exposing students to more sustainable environment would increase the possibility for the students to maintain their sustainable practices in the future.

Table 4: Activities for Adaptation Stage

Sustainability Behaviour	Never to Sometimes	Often to Always	Mean	Total Mean
Refill water bottles	35	120	4.26	3.68
Turn off lights when not in use	35	120	4.15	
Use backside of printed paper for taking notes	53	102	3.84	
Exercise	66	88	3.69	
Bike/walk to campus/classes	68	87	3.63	
Use paper/recycle bag when going out for shopping	74	81	3.53	
Recycle	88	67	3.43	
Take short showers (5 minutes or less)	88	67	3.30	
Donate unwanted belongings	92	63	3.29	

4.3 Adoption

Adoption stage involves activities that can contribute to the saving of physical environmental of the planet with the involvement of some amount of cost as shown in Table 5. The results indicate that the majority of the students are currently requesting for double-sided pages when doing photocopies or printing jobs and using public/alternative transportation when travelling (e.g. carpool). However, other activities under the adoption stage are never or only sometimes be implemented by the students. Thus, exposing students to more information on sustainable products or certified organic products and reminding them through flyers or information board in the university would increase student's knowledge towards sustainability. This shows that students are more prefer to choose activities that could save their time and money without the consideration of the environmental aspect.

Table 5: Activities for Adoption Stage

Sustainability Behaviour	Never to Sometimes	Often to Always	Mean	Total Mean
Double-sided copies and print jobs	48	107	3.89	3.34
Use public/alternative transportation (e.g. carpool)	66	89	3.66	
Purchase sustainable products (e.g. recycled paper	84	71	3.40	

notebooks)				
Purchase locally-sourced, certified organic products	95	60	3.27	
Use car for going short distances (less than 2 km)	95	60	3.15	
Use own container to 'tapau' food from cafeteria/ local stall (in campus)	105	50	3.03	
Gardening	102	53	2.96	

4.4 Application

Application stage possesses three (3) environmental friendly actions that showing the tendency of the students to share their knowledge on sustainability with others as shown in Table 6. Based on the results, majority of the students are not active in the programmes or events related to sustainability. These actions are usually influenced by the attitude of the students themselves or through the influence of their classmates/roommates. Therefore, university should organise more programmes related to sustainability and set a requirement for students who active in the programmes will have more possibility to stay in the dormitory for the following semester. As the consequences, students will be more aware towards sustainability-related programme and started to participate and share their knowledge with others.

Table 6: Activities for Application Stage

Sustainability Behaviour	Never to Sometimes	Often to Always	Mean	Total Mean
Participate in student organisations focused on sustainability	93	62	3.21	3.16
Participate in campus recreation outdoor trips	95	59	3.21	
Have conversations outside of class on sustainability issues with friends	106	49	3.05	

4.5 BIM Implementation Framework

Based on the analysis, adaptation stage is having the highest mean value compared to the other stages (adoption and application) as tabulated in Table 4, 5 and 6. This mean value is used in determining the position of each stage in the framework as proposed in Figure 1. Thus, adaptation stage is place at the following stage after awareness stage and followed by adoption stage and application stage. The results indicate that the framework is in the proper sequence and will be used in measuring the real respondents who involved in BIM implementation.

5. Conclusion

Principally, implementation of new technologies (in this context is BIM), a company need to go through step-by-step of implementation stages to avoid losses and to increase employer confidence towards the technology. Through this paper, BIM implementation process framework was proposed involving the sequence of awareness, adaptation, adoption and application. These stages allow the company to measure and understand the current stage of BIM implementation in their organisation. In order to verify the sequence of framework for adaptation, adoption and application, study related to student's daily-life activities towards sustainability was conducted. The results indicate that the framework is in the proper sequence with the highest mean value is in the adaptation stage followed by adoption and application stage. Thus, the framework will be used to measure the results from the real respondents involve with BIM implementation.

6. Acknowledgement

This study was supported by the School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia. The authors appreciate the contributions of the students involved in the data collection process.

7. References

AHMAD LATIFFI, A., MOHD, S. & RAKIMAN, U. 2015. *Potential Improvement of Building Information Modeling (BIM) Implementation in Malaysian Construction Projects,* Cham, Springer.

BEKR, G. A. 2014. Study of the Causes and Magnitude of Wastage of Materials on Construction Sites in Jordan. *Journal of Construction Engineering,* 2014**,** 6.

CONSTRUCTION INDUSTRY DEVELOPMENT BOARD MALAYSIA (CIDB) 2015. *Construction Industry Transformation Programme 2016-2020*.

CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA (CREAM) 2014. Issues and Challenges in Implementing Building Information Modeling (BIM) for SME's in The Construction Industry.

ETTLIE, J. E. 1980. Adequacy of stage models for decisions on adoption of innovation. *Psychological Reports,* 46**,** 991-995.

IKAU, R., JOSEPH, C. & TAWIE, R. 2016. Factors Influencing Waste Generation in the Construction Industry in Malaysia. *Procedia - Social and Behavioral Sciences,* 234**,** 11-18.

MALLESON, A. 2017. National BIM Report 2017. *BIM survey: summary of findings.* United Kingdom.

MCGRAW-HILL CONSTRUCTION 2014. The Business Value of BIM for Construction in Major Global Markets: How Contractors Around the World Are Driving Innovation With Building Information Modeling. *SmartMarket Report.*

MEMON, A. H., RAHMAN, I. H., MEMON, I. & AZMAN, N. I. A. 2014. BIM in Malaysian Construction Industry: Status, Advantages, Barriers and Strategies to Enhance the Implementation Level. *Research Journal of Applied Sciences, Engineering and Technology,* 8**,** 606-614.

NAGAPAN, S. A. A. R., ISMAIL AND ASMI, ADE 2011. A review of construction waste cause factors. *Asian Conference on Real Estate 2011.* Thistle Hotel Johor Bahru, Malaysia.

SENOUCI, A., ISMAIL, A. & ELDIN, N. 2016. Time Delay and Cost Overrun in Qatari Public Construction Projects. *Procedia Engineering,* 164**,** 8.

SHAH, R. K. 2016. An Exploration of Causes for Delay and Cost Overruns in Construction Projects: Case Study of Australia, Malaysia & Ghana. *Journal of Advanced College of Engineering and Management,* 2**,** 15.

SHEHU, Z., ENDUT, I. R., AKINTOYE, A. & HOLT, G. D. 2014. Cost overrun in the Malaysian construction industry projects: A deeper insight. *International Journal of Project Management,* 32**,** 1471-1480.