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Conceptual Framework for Readiness of SMEs Organization Towards BIM Implementation in Construction Projects: Pulau Pinang Case Study

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Abstract

Building Information Modelling in Malaysian context is defined as a modelling technology and associated set of processes to produce, communicate, analyze, and use of digital information models throughout construction project life cycle. Some of the common problems that occurs in construction project such as delay, the accidents that occur in construction sites and disputes between construction players can be reduced when applying BIM in their project. However, the implementation of BIM in construction sector is still low especially in Small and Medium Enterprise (SMEs) in Malaysia. To enhance the BIM implementation in Malaysia, CIDB and PWD had introduce several guidelines in terms of awareness, readiness, and execution plan as reference for the organization to fully adopted BIM effectively, however there is no existed reference used specifically for SMEs to enhance the BIM implementation in Malaysia construction projects. This research study focused on three objectives which are to explore the current existing readiness of BIM implementation among SMEs organization in construction projects, to identify the challenges of readiness for BIM implementation among SMEs organization in construction projects and to develop conceptual framework of challenges for readiness of SME organization to implement BIM in construction projects. Methodology for this research study is systematic literature review (SLR) and questionnaire survey for 40 respondents from SMEs construction sector which consists of 4 construction projects as case study. The data from questionnaire survey analyzed by using Mean and Standard Deviation for determined the rankings for the aspects. From the analysis, there are four components that involves in existing current practices which are people, government enforcement, management and technology based on the significance. Meanwhile, there are four components that involves in challenges for readiness to implement BIM which are government enforcement, people, management, and technology. Overall, a conceptual framework of challenges for readiness in SMEs organizations been developed which can be

use as a reference to enhance the implementation of BIM among SMEs organizations in ensuring towards better project quality and performance of construction projects.
Keywords: Building Information Modelling (BIM), Small Medium Enterprises (SMEs), Readiness, Challenges

Introduction

According to CIDB (2016), Building Information Modelling in Malaysian context is defined as a modelling technology and associated set of processes to produce, communicate, analyze, and use of digital information models throughout construction project life cycle. There are many countries that had applied Building Information Modelling in their project such as in United Kingdom, United States as the use of BIM in the countries is mandated (Othman et al., 2020). There are some advantages that can obtain when applying BIM in their construction project such as support to design, scheduling, and budgeting of built assets, can provides a platform to help architects to initiate the process or evolutionary design, can reduced design conflict by integrating all the key systems into the model. Besides that, some of the common problems that occurs in construction project such as delay, the increase of construction projects, the accidents that occur in construction sites and disputes between construction players can be reduced when applying BIM in their project (Latiffi et al., 2013). However, the implementation of BIM in construction sector is still low especially in Small and Medium Enterprise (SMEs) in Malaysia. To enhance the BIM implementation in Malaysia, CIDB and PWD had introduce several guidelines in terms of awareness, readiness, and execution plan as reference for the organization to fully adopted BIM effectively, however there is no existed reference used specifically for SMEs organization to enhance the BIM implementation in Malaysia construction projects. Thus, this research is important to achieve these objectives which are: (i) to explore the current existing readiness of BIM implementation among SMEs organization in construction projects, (ii) to identify the challenges of readiness for BIM implementation among SMEs organization in construction projects and (iii) to develop conceptual framework for readiness of SME organization to implement BIM in construction projects.

Literature Review

In this research, a systematic search was conducted using the Scopus search engine to identify articles related to current existing practices and challenges of readiness for SMEs organisation to implement BIM among construction organizations internationally and within Malaysia. Scopus was selected due to its accuracy and broad coverage of different research areas including management, business and engineering (Sinoh et al., 2010; Noor et al., 2021). The search was limited to articles and review papers published in academic journals after 2008. Through the general keyword title “Building Information Modelling”, this search returned 6680 references. Subsequently, two stages of screening processes were conducted to remove duplicate and unrelated articles.

In the first screening process, the full search code was TITLE-ABS-KEY ((“building information model*” AND “readiness”) AND (“BIM” AND “SME” AND (“BIM” AND “challenges”) AND (“BIM” AND “SME” AND “challenges”)) AND PUBYEAR > 2008 AND (LIMIT-TO (LANGUAGE , “English”)) was used to select relevant articles. There were 6656 articles which were removed and 124 remained. Finally, the second screening process involved the reviewing of the “full text reading” specifically focusing on the current existing practices and challenges of readiness SMEs organisation to implement BIM. A total of 94 articles were carefully removed and the remaining 30 articles were selected for a further process.

Based on the synthesize of previous literatures (i.e., Araiyici et al., 2011; Qian et al., 2012; Haron et al., 2013; Noor et al., 2022), identified four components (i.e., people, management, process and technology), which were used as references to determine the related attributes for current existing practices and challenges of SMEs readiness to implement BIM among construction organizations. Therefore, through the content analysis approach recommended by Merriam (2019), 12 attributes associated with current existing practices for SMEs to implement BIM were identified, while 13 attributes related to challenges readiness criteria for SMEs organisation in order to implement BIM were determined as shown in Table 1 and Table 2, respectively.

Current existing readiness of SME organisation implement BIM in construction projects, can be measured by observing the level of performance that had been for a task being implemented. According to the previous study (i.e., Yan & Kah, 2018), the level of BIM implementation among SMEs organisation is between Level 0 and Level 1 which is level 0 is the implementation of paper-based format and 2D-generated formats such as PDF extension and level 1 is the coordination of 3D and 2D CAD with a collaboration tool such as Extranet. This can be shown that the SMEs organisation still lacks awareness to fully implement BIM in their projects. They also stated that government involvement such as the BIM standard and policy also can be the factor of current existing readiness of BIM implementation in SMEs organisation. Thus, according to (Haron, 2013), the readiness criteria categorize into 4 components which are organisational process, management and technology. Therefore, the summarization of attributes for current practices of BIM implementation among SMEs organisation in construction projects has been highlighted in Table 1.

However, according to previous studies (i.e., Vidalakis et al., 2020 and etc) mentioned that there are several challenges facing by SMEs organisation to implement BIM in construction projects where can be classify into four main component: (1) technology; (2) management; (3) people and (4) government enforcement. A study conducted that focusing on SMEs in United Kingdom by Vidalakis et al (2020) stated SMEs tend to be concerned about existing software packages' inefficiencies and compatibility difficulties. Yan & Kah (2018) also mentioned that technology is one of the challenges in BIM implementation among SMEs in Malaysia. In terms of BIM interoperability issues in people, Haron (2013) mentioned that there is no clear advice on intellectual property rights ownership since the Architect's design, Engineer's design and analysis, Contractor's simulation model, and Fabricator's model and shop drawings are all part of the BIM interoperability model. The software interoperability issues also agreed by Haron (2013) in his study for BIM readiness mentioned the ability to do automated clash checks between PDMS and BOCAD is one of the key reasons for using BIM software. The nature of both software, which were built for separate disciplines and by different businesses, produced an interoperability difficulty during the early years of adoption, when the model created in the BOCAD program could not be immediately linked into the PDMS software. As a result, the PDMS program was unable to perform the clash check. Roslan et al (2019) stated that the BIM implementation in Malaysia is in stage 2, where the lack of financial incentive is one of the challenges faced among SME organisations in implementation of BIM. This is due to the high cost of technology and software is the critical factor that hinder the implementation of BIM in the construction. This statement is also supported and agreed by Vidalakis et al (2020) which stated that the challenges to implement BIM among SMEs is the high cost of the software.

The main attributes contributing to the challenges for SME organisation to implement BIM based on “people domains” comprise of a lack of resources and inconvenient work environment. While, the sub-domain would include the lack of resources (i.e., insufficient

resources to implement BIM in projects) including skilled personnel or training. Jones (2020) mentioned that for non-BIM users, the main reasons that the non-BIM users implement BIM is because they lacked qualified staff. Thus, they were expecting a more positive response which is enough for all the resources including the staff training. In another study by Saka et al (2020) mentioned that the resources in terms of adequate financial resources are essential elements for BIM implementation among organisations. Vidalakis et al (2020) researched the importance of sharing information with professionals that can give adequate resources in terms of knowledge. In Malaysia, Yan and Kah (2018) revealed that the expertise is one of crucial barrier to implement BIM among SMEs. This is supported by Hosseini et al (2016) that the major barrier of BIM implementation is a lack of expertise among organisations in BIM projects.

Besides, the other domains related to challenges readiness for SME organisation to implement BIM are lack of standard policy and lack of government support. The sub-domain involved in lack of standard and policy is lack of government policy (standards and guidelines) for SMEs to implement BIM in construction projects. A study of the current BIM practices in Malaysian construction organisation for the stakeholders' perspective by Ng et al (2018) mentioned that the most critical issues lie with the fact that there is still a lack of guidelines and enforcement to cater for the construction players. Government agency is taking the lead and is currently in the process of establishing a guideline. Every organisation should also establish a standard of practice internally. Thus, it is not only the government roles, but the organisation also play roles to establish a standard for internal uses Besides, another study for a review implementation BIM in Malaysia by Haron et al (2017) highlighted that in building projects, BIM changes conventional procedures and, therefore, construction organisations need to adapt to modern business processes. However, it is impossible to predict the implications due to the immaturity of users and the lack of explicit guidelines. A study that had been done in context of contractor's perception of the BIM adoption in Nigerian construction industry, by Abubakar et al (2014) stated that the lack of standards to guide implementation was ranked as No. 9 among the 12 barriers listed to implement BIM in the Nigerian Construction Industry.

Next, the attributes that involve in lack of government support are lack of government mandate to adopt BIM among contractors in local projects and lack of government support in providing organisation enhancement in terms of training and others. There is no clear statement stated in their contracts that addresses the mandatory obligation for BIM use. In addition, there is no strong procurement project delivery that mandates the usage of BIM. Furthermore, all projects must be based on contracts. As a result, rather than just adding BIM as an amendment, the construction contract must be amended by adding a specific statement to embrace BIM adoption (Ng et al., 2018). In addition, according to Haron et al (2017), despite the government's involvement in BIM implementation, Malaysia is still trailing behind the rest of the world. For the lack of government support in providing organisation enhancement in terms of training and others, Saka et al (2020) mentioned the lack of official backing for BIM is the key issue facing in most countries. In addition, it concluded that government-backed incentives, in particular, can help to reduce cost-related barriers (Jones, 2020). Therefore, the summarization of attributes for challenges readiness for BIM implementation among SMEs organisation in construction projects has been highlighted in Table 2.

Table 1

Summarization of Attributes for Current Existing Practices for Readiness of SMEs Organization Towards BIM Implementation

Main Domain	Domain in current practices for readiness among SMEs to implement BIM	Attribute	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	Total Hits
Technology	Resources to upgrade software and hardware	BIM software and hardware can be upgraded with sufficient resources.	/			/						/									/	4
	Compatibility of Software	BIM can be used in BIM projects by AEC (Architecture, Engineering, and Construction) players.		/										/					/			3
	Complexity of BIM	BIM is a complex software package that is used in BIM projects.		/										/					/			3

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al.,

2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2014), R19: (Haron, 2013)

Table 1
Summarization of Attributes for Current Existing Practices for Readiness of SMEs Organization Towards BIM Implementation (Continue)

Main Domain	Domain in current practices for readiness among SMEs to implement BIM	Attribute	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	Total Hits
Management	Management Process Strategy	BIM provides AEC players to increase their productivity by collaborating and sharing information with one another	/	/					/			/									/	5
		BIM provide necessary to modify a series of activities by evaluating current business process				/						/					/				/	4
	Leadership	BIM implementation can be helped by management leadership							/				/			/						3
		BIM implementation can be aided by sufficient organisational support		/		/			/					/	/	/	/		/	/	/	10
	Business strategy	BIM implementation in the organisation is highly demand in future market	/											/						/		3

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al., 2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2014), R19: (Haron, 2013)

Table 1
Summarization of Attributes for Current Existing Practices for Readiness of SMEs Organization Towards BIM Implementation (Continue)

Main Domain	Domain in current practices for readiness among SMEs to implement BIM	Attribute	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	Total
People	Training and skill	BIM implementations need necessarily requirement for training and educational program.	/		/	/	/				/	/										6
		BIM in a construction projects acquire individual able to operate it.											/									1
	Awareness	BIM software is necessary to educate AEC players on how to use								/	/		/					/	/		/	6

		in their projects.																					

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al., 2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2014), R19: (Haron, 2013)

Table 1
Summarization of Attributes for Current Existing Practices for Readiness of SMEs Organization Towards BIM Implementation (Continue)

Main Domain	Domain in current practices for readiness among SMEs to implement BIM	Attribute	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	Total Hits
Government Enforcement	Legal policy	BIM adoption can result in a maintainable well-defined policy (standards and guidelines). etc: Public Work Department (PWD/JKR) BIM)					/	/	/	/		/							/		/	7
		BIM adoption can align the requirement for the government to mandate it in the future.	/	/			/															3

	Government Support	BIM adoption among AEC firms if there is a government support.						/	/							/							3

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al., 2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2015), R19: (Haron, 2013)

Table 2

Summarization of Attributes for Challenges Readiness For SMEs Organization Towards BIM Implementation

Main Domain	**Domain in challenges of readiness to implement BIM among SMEs**	**Attributes**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**	**R17**	**R18**	**R19**	**R20**	**Total**
Technology	Software interoperability issues	When using BIM in construction projects, there are software interoperability issues.								/		/	/									/	4
	Lack of financial incentive	High initial investment to adopt BIM in a project.							/	/					/			/					3
		Lack of utilizing/ unaware financial incentive provided.						/				/						/				/	4

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al., 2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2015), R19: (Haron, 2013)

Table 2
Summarization of Attributes for Challenges Readiness For SMEs Organization Towards BIM Implementation (Continue)

Main Domain	Domain in challenges of readiness to implement BIM among SMEs	Attributes	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	Total
Management	Lack of leadership management	Lack of organisational support during the adoption stage	/											/				/					3
	Lack of Management Competency	BIM implemented in a project's changes workflow complexity			/		/														/	/	4
		Lack of communication among the organisation's stakeholders				/								/	/								3
People	Lack of Resources	Insufficient resources to implement BIM in projects (for example, skilled personnel or training).	/	/						/	/	/								/	/		7
	Inconvenient Work Environment	Implementation of BIM is not well-known among AEC players.						/				/			/		/				/		5

		Lack of knowledge and understanding of BIM work environment/structure .	/					/	/			/		/	/		/	/	/				9
		Reluctance to change the work environment from conventional to BIM adoption.									/	/		/				/	/			/	6

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al., 2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2015), R19: (Haron, 2013)

Table 2

Summarization of Attributes for Challenges Readiness For SMEs Organization Towards BIM Implementation (Continue)

Main Domain	**Domain in challenges of readiness to implement BIM among SMEs**	**Attributes**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**	**R17**	**R18**	**R19**	**R20**	**Total**
Government Enforcement	Lack of standard and policy	Lack of government policy (standards and guidelines) for SMEs to implement BIM in construction projects.	/								/	/	/	/			/	/	/		/		9
	Lack of Government Support	Lack of government mandate to adopt BIM among										/		/			/				/		4

		contractors in local projects.																				
		Lack of government support in providing organisation enhancement in terms of training etc.	/	/											/							3

R1:(Jones, 2020), R2: (Saka et al., 2020), R3: (Muhammad & Mustapa, 2020), R4: (Hatmoko et al., 2019), R5: (Liao et al., 2019), R6: (Roslan et al., 2019), R7: (Vidalakis et al., 2018), R8: (Yan & Kah, 2018), R9: (Ng et al., 2018), R10: (Kouch et al., 2018), R11: (Abd Hamid et al., 2018), R12: (Chen et al., 2017), R13: (Lam et al., 2016), R14: (Lee & Yu, 2016), R15: (Lindblad & Vass, 2015), R17: (Hanafi et al., 2016), R18: (Poirier, 2015), R19: (Haron, 2013)

Methodology

In the initial stage, a systematic literature review (SLR) was conducted to explore the attributes relating to current existing practices and readiness criteria of SME organisation to implement BIM in the projects. Subsequently, the questionnaires survey was selected as the method of data collection involving 40 practitioners (i.e., client, consultant and contractor) among the selected four case studies projects in Pulau Pinang. Due to Covid-19 pandemic, the questionnaires were distributed using Google Form and telephone interview. The responses from the respondents were sufficient and satisfying to present the four case studies in Pulau Pinang. According to Noor et al (2019), selection of case studies is appropriate to describe the detailed study of single groups or organisations and projects. The closed-ended questions had been designed comprising of two parts (i.e., respondent profiles and assessment of attributes that are related to current existing practices and challenges readiness criteria of SME organisation for BIM implementation). This set of survey used the 5-point of Likert-type scale (1: not important to 5: highly important). The data collection were process through Statistical Package for the Social Science (SPSS) version 26.0. The ranking analysis was executed based on mean value and standard deviation as suggested by Sinoh et al (2010); Noor et al (2018), to indicate the rank for the attributes related to the current existing practices and challenges readiness criteria of SME organization for BIM implementation.

Profile of Respondents

In overall, there was a good mixture of organisation of respondents from three main entities (i.e., client, consultant and contractor), whereby a majority of respondents (98 per cent) were consultants and contractors as practitioners who were directly involved in the management and operations in project working practices (see Table 3). On average, the respondents had about more than 10 years of experience in the construction industry and there were only 28 percent) of respondents who had experienced the use of BIM during the working process. This is in line with the report highlighted in 2016, where (17 per cent) of Malaysian

practitioners had experience in BIM which shows a lack of diffusion of BIM within the construction organization in projects (CIDB, 2017).

Table 3
Respondent's Background

Profile	Description	Percentage (%)
Types of Organisation	Client	2
	Contractor	82
	Consultant	16
Designation	Engineer	35
	Project Engineer	20
	Assistant Engineer	17
	Supervisor	5
	Others	5
Experience in Construction Industry	More than 20 years	1
	6 – 10 years	44
	1 - 5 years	42
	Less than 1 year	13
Experience in BIM Utilization	Yes	28
	No	72

Ranking Analysis and Findings

This section presents the ranking of the attributes and components related to the current existing practices of BIM implementation among SMEs organizations in projects as indicated in Table 4. Ranking analysis assigns a number to each attribute to indicate its rank based on their mean and standard deviation values. Having ranked the attributes and component for current practices of BIM implementation among SME organization in projects, the ranking analysis indicates that the highest mean values for component was "People" (mean value = 4.22) was given rank of 1, which comprised of the top two domain (e.g, training and skills and awareness). Training and skill domain comprise two attributes including "BIM implementations need necessarily requirement for training and educational program" (mean value = 4.17), and "BIM in a construction projects acquire individual able to operate it" (mean value = 4.25). While awareness domain consist of attributes "BIM software is necessary to educate AEC players on how to use in their projects." (mean value = 4.25).

Meanwhile, "government enforcement" component was ranked as No. 2 which highlighted three important attributes for current practices of BIM implementation among SME organization comprised of two main domains (i.e., legal policy and government support). There two attributes highlighted under "legal policy domain" which include the "BIM adoption can result in a maintainable well-defined policy (standards and guidelines)." (mean value = 4.27), and "BIM adoption can align the requirement for the government to mandate it in the future" (mean value = 4.15) and there is attribute of "BIM adoption among AEC firms if there is a government support" (mean value = 4.15) contribute to the "government support domain".

In addition, component for "management" has been ranked as No. 3, whereby this component was underpinned with three main domains with five main attributes. The first domain related to management is "management process strategy" comprised attributes that have the mean values which described current existing practices for BIM implementation

including “BIM provides AEC players to increase their productivity by collaborating and sharing information with one another” (mean value = 4.05), followed with “BIM provide necessary to modify a series of activities by evaluating current business process” (mean value = 3.90). While, the second domain is “leadership” comprised two attributes including “BIM implementation can be helped by management leadership” with (mean value = 4.10) and “BIM implementation can be aided by sufficient organisational support “ (mean value = 4.17), respectively. The third domain is “business strategy” comprised of attribute of “BIM implementation in the organisation is highly demand in future market” with (mean value = 4.20).

Subsequently, the “technology” component was ranked as No 4, which described that most of the respondents have been exposed to BIM tools with (mean value = 4.05). The mean value was showing that the "important" contributed to the current existing practices, in this study this component was considered as part of essentials and appropriate attributes that are able to describe the real current practices of readiness of BIM implementation among SME organisation in the context of Pulau Pinang due to the paucity of BIM implementation in this northern region as highlighted by CIDB (2017). For “technology” component, it comprised of there domain with three separate attributes. The “Resources to upgrade software and hardware” consists of attribute of “BIM software and hardware can be upgraded with sufficient resources” with (mean value = 4.12) and domain of “Compatibility of Software“ comprised of attribute of “BIM is a complex software package that act as complexity ease in construction projects” with (mean value = 3.97) and domain of “Complexity of BIM” consist of attribute of “BIM is a complex software package that is used in BIM projects” (mean value = 4.05) which describe the current existing of readiness for BIM implementation among SME in the context of technology as the findings suggest.

Table 4
Ranking Analysis for Readiness Criteria of BIM Implementation among SME Construction Organisation in Projects Based on Mean Value and Standard Deviation

Main Domain	Domain of Current Practice	Attribute	Mean of Attribute	Std Deviation of Attribute	Rank for Attribute	Mean of Domain Current Practice	Std Deviation of Domain Current Practice	Rank for Domain Current Practice	Mean for Overall	Std Deviation Overall	Rank for Overall
People	Training and Skills	BIM implementations need necessarily requirement for training and educational program.	4.17	1.08	3	4.21	0.92	2	4.22	0.92	1
		BIM in a construction projects acquire individual able to operate it	4.25	1.03	2						
	Awareness	BIM software is necessary to educate AEC players on how to	4.25	1.05	1	4.25	1.05	1			

		use in their projects.									
Government Enforcement	Legal Policy	BIM adoption can result in a maintainable well-defined policy (standards and guidelines). etc: Public Work Department (PWD/JKR) BIM)	4.27	1.08	1	4.21	1.08	1	4.19	1.00	2
		BIM adoption can align the requirement for the government to mandate it in the future.	4.15	1.16	2						
	Government Support	BIM adoption among AEC firms if there is a government support.	4.15	1.21	3	4.15	1.21	2			

Table 4

Ranking Analysis for Readiness Criteria of BIM Implementation among SMEs Construction Organisation in Projects Based on Mean Value and Standard Deviation (Continue)

Main Domain	Domain of Current Practice	Attribute	Mean of Attribute	Std Deviation of Attribute	Rank for Attribute	Mean of Domain Current Practice	Std Deviation of Domain Current Practice	Rank for Domain Current Practice	Mean for Overall	Std Deviation Overall	Rank for Overall
Management	Management process strategy	BIM provides AEC players to increase their productivity by collaborating and sharing information with one another.	4.05	1.10	4	3.97	0.96	3	4.08	0.87	3
		BIM provide necessary to modify a series of activities by evaluating current business process.	3.90	1.00	5						
	Leadership	BIM implementation can be helped by management leadership.	4.10	1.00	3	4.13	0.89	2			
		BIM implementation can be aided by sufficient organisational support.	4.17	0.98	2						
	Business Strategy	BIM implementation in the organisation is highly demand in future market.	4.20	0.99	1	4.20	0.99	1			
Technology	Resources to upgrade software and hardware	BIM software and hardware can be upgraded with	4.12	1.11	1	4.13	1.11	1	4.05	0.97	4

		sufficient resources.									
	Compatibility of Software	BIM is a complex software package that act as complexity ease in construction projects.	3.97	1.16	3	3.97	1.16	3			
	Complexity of BIM	BIM is a complex software package that is used in BIM projects.	4.05	1.06	2	4.05	1.06	2			

Table 5 shows the results for the challenges of readiness criteria which influenced the BIM implementation among SME organization which comprised of four components (i.e. government enforcement, people, management, and technology) that underpinned several essential vital components that drive the BIM implementation in the project organisation. The results in Table 5 highlighted that this component was influenced by two criteria including "government enforcement" which ranked as No. 1, followed by two main domain "Lack of standard and policy" and "Lack of Government Support" with overall mean of 4.37 and 4.27 respectively. As described in the results, there were attribute of "Lack of government policy (standards and guidelines) for SMEs to implement BIM in construction projects" with (mean value = 4.37) that need to be emphasized and there were another two attribute underpinned under domain of "Lack of Government Support" which include "Lack of government mandate to adopt BIM among contractors in local projects" with (mean value = 4.27), and "Lack of government support in providing organisation enhancement in terms of training and others" with (mean value = 4.27).

Meanwhile, "people" component was ranked as No. 2 which highlighted two important domains with four attributes for challenges readiness of BIM implementation among SME organization. The attributes highlighted under "Lack of Resources" is "Insufficient resources to implement BIM in projects (for example, skilled personnel or training)"(mean value = 4.10), and another three attributes underpinned to "Inconvenient Work Environment" domain are "Implementation of BIM is not well-known among AEC players (mean value = 4.10), "Lack of knowledge and understanding of BIM work environment/structure" (mean value = 4.20) and " Reluctance to change the work environment from conventional to BIM adoption" (mean=3.95).

In addition, component for "management" has been ranked as No. 3, whereby this component was underpinned with three main domains with three main attributes. The first domain related to management is "Lack of leadership management" comprised attributes that have the mean values which described challenges readiness for BIM implementation among SME organisation including "Lack of organisational support during the adoption stage" (mean value = 4.07). While, the second domain is "Lack of Management Competency" comprised two attributes including "BIM implemented in a project's changes workflow complexity" with (mean value = 3.97) and "Lack of communication among the organisation's stakeholders" (mean value = 4.12), respectively.

Subsequently, the “technology” component was ranked as No 4, which described that most of the respondents have been exposed to BIM tools with (mean value = 3.77). The mean value was showing that the "important" contributed to the challenges readiness of SME organisation towards BIM implementation, in the context of Pulau Pinang. For “technology” component, it comprised of there domain with three separate attributes. The domain of “Software interoperability issues” consists of attribute of “When using BIM in construction projects, there are software interoperability issues” with (mean value = 3.80) and domain of “Lack of financial incentive“ consist of attributes of “High initial investment to adopt BIM in a project” with (mean value = 3.67) and “Lack of utilizing/unaware financial incentive provided” (mean=3.72). While, the domain of “Lack of BIM hardware and software” comprised attribute of “Lack of BIM hardware and software” with (mean value = 3.90) which describe the challenges of readiness for BIM implementation among SME in the context of technology as the findings suggest”

Table 5

Ranking Analysis for Challenges of Readiness Criteria of BIM Implementation among SMEs Construction Organisation in Projects Based on Mean Value and Standard Deviation

Main Domain	Domain of Challenges in Implementation of BIM	Attribute	Mean of Attribute	Std Deviation of Attribute	Rank for Attribute	Mean for Domain Challenges	Std Deviation of Domain Challenges	Rank for Domain Challenges	Overall Mean	Overall Std Deviation	Overall Rank
Government Enforcement	Lack of standard and policy	Lack of government policy (standards and guidelines) for SMEs to implement BIM in construction projects	4.37	0.86	1	4.37	0.86	1	4.30	0.84	1
	Lack of Government Support	Lack of government mandate to adopt BIM among contractors in local projects.	4.27	0.93	2	4.27	0.90	2			
		Lack of government support in providing organisation enhancement in terms of training and others.	4.27	0.93	3						
People	Lack of Resources	Insufficient resources to implement BIM in projects (for example, skilled personnel or training)	4.10	0.98	3	4.10	0.98	1	4.08	0.83	2
	Inconvenient Work Environment	Implementation of BIM is not well-known among AEC players.	4.10	1.00	2	4.08	0.83	2			
		Lack of knowledge and understanding of BIM work environment/structure	4.20	0.91	1						
		Reluctance to change the work environment from conventional to BIM adoption.	3.95	0.98	4						

Table 5

Ranking Analysis for Challenges of Readiness Criteria of BIM Implementation among SMEs Construction Organisation in Projects Based on Mean Value and Standard Deviation (Continue)

Main Domain	Domain of Challenges in Implementation of BIM	Attribute	Mean of Attribute	Std Deviation of Attribute	Rank for Attribute	Mean for Domain Challenges	Std Deviation of Domain Challenges	Rank for Domain Challenges	Overall Mean	Overall Std Deviation	Overall Rank
Management	Lack of leadership management	Lack of organisational support during the adoption stage.	4.07	1.16	2	4.07	1.16	1	4.05	0.98	3
	Lack of Management Competency	BIM implemented in a project's changes workflow complexity.	3.97	1.02	3	4.05	1.01	2			
		Lack of communication among the organisation's stakeholders.	4.12	1.04	1						
Technology	Software interoperability issues	When using BIM in construction projects, there are software interoperability issues.	3.80	1.18	2	3.80	1.18	2	3.77	0.99	4
	Lack of financial incentive	High initial investment to adopt BIM in a project.	3.67	1.14	4	3.70	1.06	3			
		Lack of utilizing/unaware financial incentive provided	3.72	1.08	3						
	Lack of BIM hardware and software	Lack of BIM hardware and software compatibility.	3.90	1.08	1	3.90	1.08	1			
	Lack of Management Competency	BIM implemented in a project's changes workflow complexity.	3.97	1.02	3	4.05	1.01	2			
		Lack of communication among the organisation's stakeholders.	4.12	1.04	1						

In overall, it could be concluded that all of 12 attributes related to current practices readiness of SME organisation towards BIM implementation and 18 attributes of challenges readiness of SME organization to implement BIM has been consolidated in a form of conceptual framework as described in Figure 1. Towards implementing the success of BIM in the projects, the readiness of SME organisation is a part of a necessity that needs to be particularly highlighted in order to ensure the level of awareness and preparedness of an organisation is in the optimum level to execute BIM comprehensively. The readiness of an organisation is based on the four main components (i.e., people, management, government enforcement and technology), which are considered as intercorrelated in each other. For example, the people component is a central of component that specifically acts as the main driver to nurture the readiness of an SME organisation towards BIM. This component should be

underpinned with the (i.e., management, government enforcement and technology) in order to provide the optimum level of readiness among SME organisations to successfully implement BIM for projects.

Kouch et al (2018) highlighted the success of BIM implementation is influenced by the readiness and awareness level of organisation in the early stage of involvement for project. Therefore, through this conceptualize framework, it could assist the SME construction practitioners to enhance their understanding and awareness to fully prepare before executing BIM in the projects and also could act as a reference for best practices of BIM implementation in the working practice environment.

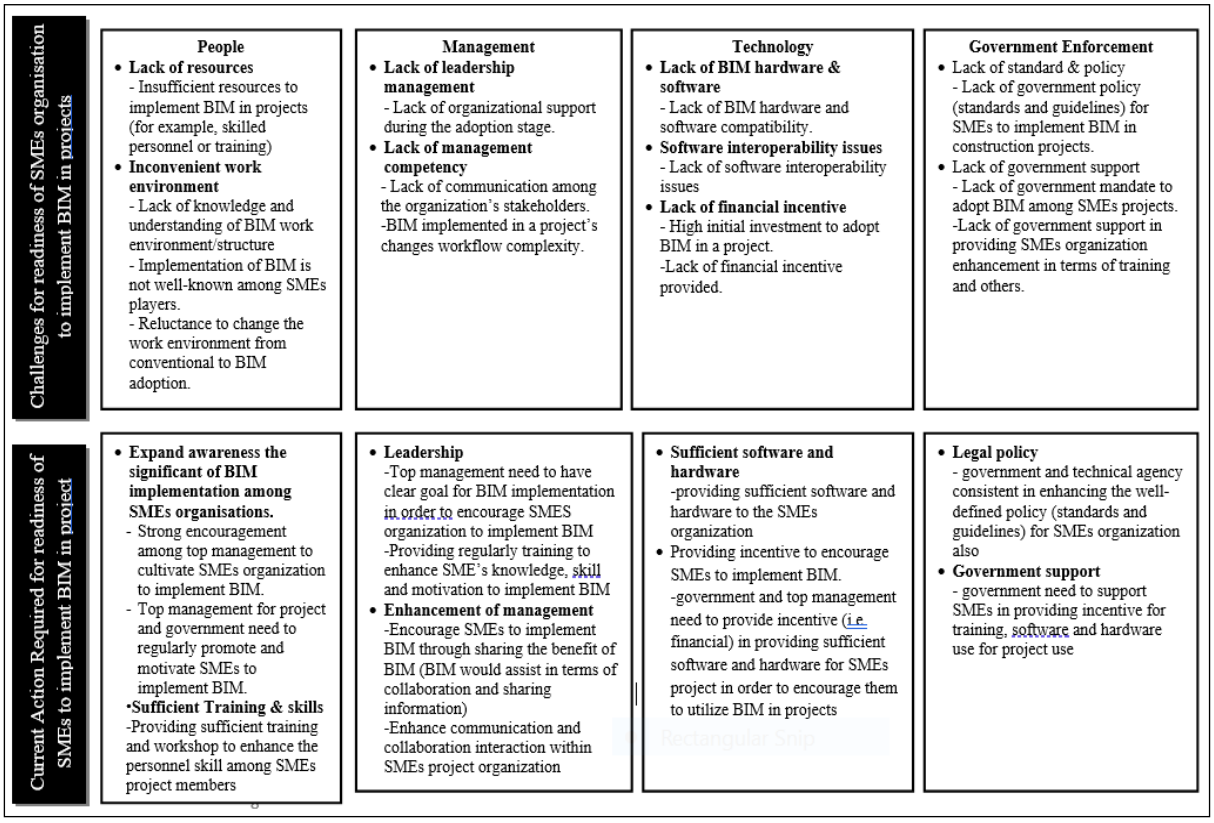

Figure 1. Conceptual framework for readiness of SMEs organisation for BIM implementation in construction projects

Conclusion

This study has provided an overview of the attributes related to the current existing and challenges readiness criteria for BIM implementation among SME construction organisations in the Pulau Pinang context. Based on the questionnaire survey with response from construction practitioners, this study assessed the importance of related attributes to prepare the readiness of SME organisations towards the success of BIM implementation in the projects. The findings identified 12 attributes of current practices and 18 attributes for challenges readiness criteria which has been classified into four main components (i.e., people, management, government enforcement and technology) which has further been consolidated in the conceptualize framework (see Figure 1), that needs to be emphasized for organisation readiness in order to execute BIM in projects.

This study showed that practitioners' knowledge and experience at a variety of levels in construction environments can result in generating responses that are linked with real construction practices. Therefore, the proposed conceptualize framework could be applied

for construction practitioners as a point of reference to gain a better understanding in achieving the optimum level of readiness among SME organisation towards the implementation of BIM comprehensively in projects. Consequently, this initiative could drive and cultivate the practitioners towards achieving construction strategy 4.0 in changing the direction of working environment via advanced technology tool implementation.

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