ASEAN Engineering Journal

Full Paper

BUILDING INFORMATION MODELLING (BIM) CAPABILITY IN MALAYSIAN ARCHITECTURAL PRACTICES

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Article history
Received
18 April 2022
Received in revised form
08 August 2022
Accepted
22 September 2022
Published online
28 February 2023

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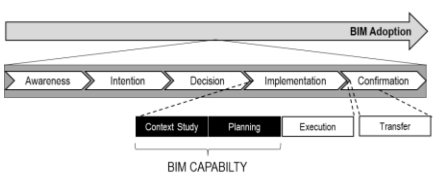
Graphical abstract



Abstract

The wave of IR 4.0 has created a competitive environment by transforming the industry in both technical and managerial aspects. Many studies have highlighted the need for a radical shift of conventional design processes in the concept of BIM as a management and collaboration platform. Hence, an effective strategy for the BIM implementation process is needed by developing different BIM capabilities in different cascades of BIM stages. The aim of this study is mainly to investigate BIM capabilities developed by current architectural practices. Six BIM capabilities identified from extensive literature review were Design Authoring, Design Visualisation and Simulation, Design Coordination and Review, Constructability Analysis, Project Changes Management, and Collaboration and Coordination. Each BIM capability were studied according to different BIM activities that must be performed. The data on current capabilities developed by architectural firms were collected through questionnaire survey that was distributed in Klang Valley, Malaysia. The findings revealed different BIM capabilities acquired by the architectural firms in three different BIM stages. For architectural firms in stage 1 BIM implementation, the most acquired BIM capability are Design Authoring, Design Visualisation and Simulation and Constructability Analysis. In BIM stage 2 practices, Constructability Analysis, Collaboration and Coordination, and Design Authoring capabilities were developed. The practices which claimed to be in stage 3 BIM dominated in terms of Design Visualisation and Simulation, Collaboration and Coordination and Design Authoring. The current BIM capabilities will be the basis to suggest critical BIM capabilities that current architectural practices in Malaysia should seek.

Keywords: Building Information Modelling (BIM), architecture, BIM capability, organisational capabilities, BIM activity

1.0 INTRODUCTION

The emergence of advanced technology has resulted to the Fourth Industrial Revolution (IR 4.0) through several digital transformations such as Artificial Intelligence (AI), Internet of Things (IoT), Virtual Reality (VR), Augmented Reality (AR), Cloud Computing, Cognitive Computing and big data. These digital transformations could enhance the performance of various industries including the construction industry [1]. Building Information Modelling (BIM) is not an exception from IR 4.0. BIM was clustered by Oesterreich & Teuteberg [2] as one of the key technologies that appear in the form of simulation and modelling in IR 4.0.

Today, the concept of digitising and connectivity of IR 4.0 in the construction industry using BIM has expanded from the ability to use the Augmented Reality (AR) applications to provide the stakeholders and construction workers the visual representations of the construction job on sites to the ability to track the facility and assets for the facility management (FM) solving the visibility issues using the real-time digital data available in the model [3, 4].

In Malaysia, in line with IR 4.0, several efforts have been made by the government agencies including establishment of Public Works Department (PWD) Strategic Plan 2021-2025, Construction 4.0 Strategic Plan 2021-2025 and the recent released National Construction Policy 2030 (NCP 2030). In realisation to the commitment of BIM implementation in Malaysia, government also committed to have 50% of federal building and infrastructure projects valued at RM10 million and above to be using BIM in their projects. These efforts are vital to increase BIM adoption by the construction players in Malaysia.

However, local studies [7, 8] and the latest survey conducted by CIDB in 2019 [9] have shown that the BIM adoption rate is still at 49% reflecting a relatively low value compared to other leading countries in Asia. Despite thorough discussions of BIM benefits from pre-construction to post construction stages [6], there are still many challenges that hinders successful BIM adoption in different transformation stages within organisational context [10, 11, 12]. As a result, the organisations always hesitate when it comes to deciding to adopt BIM after initiating the BIM implementation process [13].

One of the reasons for slow BIM adoption is that the organisations are unaware of which BIM functions need to be pursued to develop the BIM capabilities and achieve the expected benefits. Organisations that are interested and starting to adopt BIM must strategically manage the implementation process. Based on the theory of Dynamic Capabilities Framework by Teece [14], adapting an organisation's resources and capabilities to respond to the rapid technological changes is the foundation to sustain the organisation. Various studies also support these theories that highlight the importance of developing an organisation's capability to remain relevant in the competitive construction industry [15, 16]. Failure to identify BIM functions and related capabilities could result in ineffective BIM implementation [16].

Secondly, it is necessary to determine the hierarchy of each BIM capability to be developed [16] at different levels or stages. Othman, Al-Ashmori, Rahmawati, Amran, & Al-Bared [10] have discussed the transformation in each BIM stage according to Succar [12]. It has been elaborated further through the BIM Steps Matrix that organisations must identify each activity, service, and product necessary to fulfil each requirement of the BIM stages to move forward. These differences create the relative importance of each BIM capability to be developed by the organisations to improve BIM implementation efficiency. Hence, prioritising capabilities development according to the BIM implementation stages could guide the organisations to focus on yielding the maximum capacity of BIM benefits.

Substantial studies discuss the factors contributing to the low BIM adoption rate in Malaysia. Regardless, none of them has identified which BIM capabilities should be sought by the organisations in different adoption points during the implementation process. Ismail, Drogemuller, Beazley, & Owen [17] and Wong, Salleh, & Rahim [18] identified various BIM capabilities needed in the local context. However, these studies are limited to Quantity Surveying practices. A recent study by Ahmad Jamal, Mohammad, & Hashim [8] reviewed relevant BIM capabilities in architectural practices categorised under different project lifecycles. Despite providing insight about BIM capabilities, this study did not help in deciding the importance of each BIM capability in the organisation's strategic implementation. Generally, most local studies highlight the potential improvements or barriers to BIM implementation related to BIM competencies, such as the people, technology, and policy requirement factors [13, 11, 8, 19, 7]. These studies suggest increasing organisation competencies without addressing the purpose of investing in each asset capability.

However, according to the study done by Hochscheid & Halin, 2020 [20], one of the steps to integrate BIM into practices in the 'context study' and 'planning' phase is to first determine the different needs and demands between practices to set up specific goals on skills and capability building as shown in Figure 1. In this situation, the adopter needs to know what skills and capabilities could be developed according to the different needs and resources so that the substantial investment in training and software could practically impact the transition. Despite the provision of available guidelines and standards such as CIDB BIM Guidebook 2016 and Malaysian JKR BIM Standards 2014, current architectural practices mostly did not apply and overlooked the strategic process of BIM implementation due to the lack of clarity in the adoption process [20]. This results in ineffective standard and guideline issues [8]. Hence, more studies are being done to propose a more detailed and practical procedure for the BIM implementation within the series of adoption processes [20, 21, 22, 23], especially for architectural practices.

Therefore, this study intervenes the BIM implementation process to elucidate and specify what type of activities and skills could be developed and practised in the current industry as per Figure 1. This paper aims to investigate the BIM capabilities developed by current architectural practices in Malaysia in the different BIM stages. This can be achieved by first identifying BIM activities that could be performed and then determining the capabilities related to it. The study contributes to the body of knowledge by highlighting the current level of BIM capabilities to be used as a basis to further investigate on the proposal of critical BIM capabilities that should be sought by the firms. The identified capabilities will help to increase awareness on the importance of BIM capabilities in each organisation within the BIM implementation process.

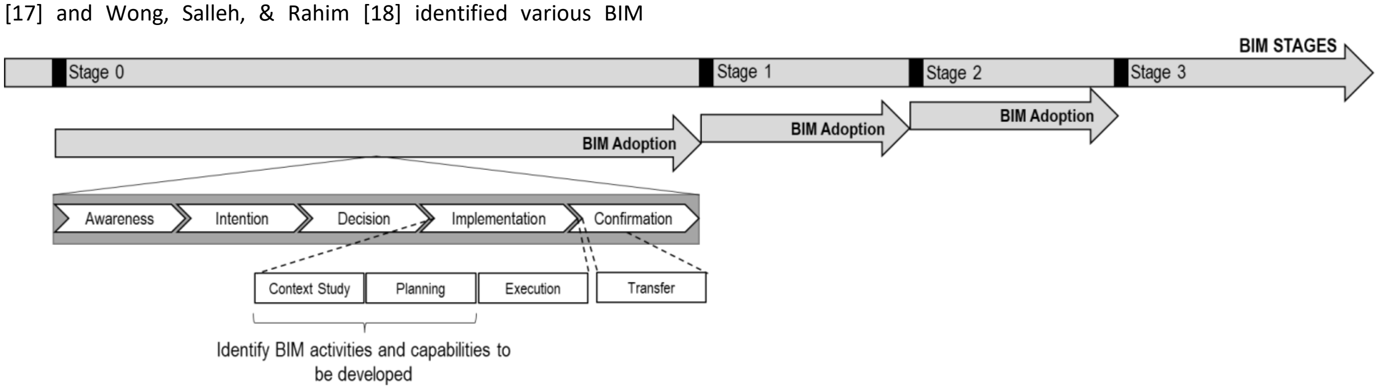


Figure 1 The study concerned on BIM activities and capability building that revolves around the implementation phase within the BIM adoption process in different BIM stages adapted from Hochscheid & Halin [20] and Succar [12]

2.0 LITERATURE REVIEW

A handful of past studies conducted have explored the topic of BIM capability [16,18,25,37]. The term 'capability' refers to 'the basic ability to perform a task or deliver a BIM service or product' [24]. In organisational context, the term 'organisational capability' relates to the 'outcomes of an organisation's activities that contributes to business results and it is the by-product of the organisation's investment such as training and staffing' [16,25]. Therefore, for this study, BIM capability refers to the organisation's basic ability to perform respective BIM activities.

The study of BIM capabilities is needed for the organisation in relation to the company's strategic changes. Identification of right capabilities within the organisation could accelerate BIM adoption through a well-defined approach of understanding BIM and its relevant functions. Hence, capability building through different BIM activities could be performed based on organisation's available resources and different competency areas such as technology, process, human, policy and so forth.

Although several studies have identified various BIM capabilities [16,18,25,37], there is a need for organisations to develop their own BIM capabilities that specifically relates to the organisational activities. To date, there have been no study attempted to identify the BIM capabilities within architectural practices. Thus, in order to achieve the aim for this study, an extensive literature review was conducted based on initial BIM capabilities established by Ahuja, Sawhney, & Mohammed Arif [16]. The BIM capabilities were also grouped according to BIM activities related to architectural practices based on the RIBA Plan of Work 2020. These BIM capabilities were validated through in-depth interview with BIM experts in the industry. Finally, there were six BIM capabilities related to the practices in Malaysia, namely Design Authoring, Design Visualisation and Simulation, Design Coordination and Review, Constructability Analysis, Project Changes Management as well as, Collaboration and Coordination. The final list of BIM capabilities related to architectural practices based on BIM activities performed is captured in Table 1. In addition, it is important to further highlight the current BIM capabilities in different BIM stages as different activities and capabilities are required for the organisations to transform from one stage to another [24].

Table 1 BIM capabilities and BIM activities in architectural practices

No.	BIM Capabilities and BIM Activities	References
	C1: Design Authoring	
C1A1	Create a BIM model using 3D parametric modelling software such as Autodesk Revit, ArchiCAD, Vectorworks	[26, 27, 28]
C1A2	Manipulate, navigate, and review the 3D BIM model created	[26]
C1A3	Use the 3D BIM model for conceptual massing	[8]
C1A4	Use the 3D BIM model for conceptual modelling	[29, 30, 28, 17]
C1A5	Use the 3D BIM model for design and spatial planning	[29, 30, 28, 17]
C1A6	Use the 3D BIM model for detailed modelling	[29, 30, 28, 17]
	C2: Design Visualisation and Simulation	
C2A1	Communicate design ideas using the 3D BIM models created	[31, 32, 29, 33]
C2A2	Produce any forms of simulations using BIM tools	[31, 26]
	C3: Design Coordination and Review	
C3A1	Conduct coordination meetings to identify potential design errors and discrepancies using a federated BIM model	[27, 34]
C3A2	Produce 3D base architecture model in LOD 300- LOD 400	[35]
C3A3	Produce parametric modelling to allow consistent changes (using parameters) during the design coordination and review process	[34, 36, 37]
C3A4	Use any coordination software such as Naviswork to identify and resolve the coordination issues	[38]
C3A5	Export the 3D BIM model to any neutral format (e.g.; IFC, VRML) for design review presentations	[39]
C3A6	Participate in BIM e-submission (NBeS) for code compliance checking	[27, 8, 16, 30]
	C5: Constructability Analysis	
C5A1	Conduct clash analysis from the federated BIM model before the construction stage	[35, 40]
C5A2	Develop construction documents that consist of 3D BIM models up to LOD 300 as deliverables before construction stage	[35]
C5A3	Develop construction documents that consist of 2D drawings (generated from the 3D model) as deliverables before the construction stage	[35]
C5A4	Develop construction documents that consist of technical documents and specifications (generated from the 3D model) as deliverables before the construction stage	[35]
	C6: Project Changes Management	
C6A1	Share updated model and clarify changes to other parties/ disciplines in a BIM project at the same time	[41, 42]
C6A2	Use any tools to track change history and change consequences done by other parties such as BIMestiMate, etc	[41, 42]
C6A3	Synchronise changes to all project team members automatically without redelivery of changed information	[39]
	C7: Collaboration and Coordination	

C7A1	Develop a collaborative mindset that considers various party's input to produce the deliverables	[43]
C7A2	Use any cloud-based shared data environment/server such as BIM 360, Buzzsaw, or WebEX	[44, 8]
C7A3	Use the collaboration tools mentioned to synchronise and share the 3D BIM model	[45]
C7A4	Use the collaboration tools mentioned (if any) to synchronise and share other documents (e.g.; drawings, audio-visual information, information query, notifications)	[45]
C7A5	Develop the CDE structure to determine the information management in 4 stages (according to standard BS 1192) (e.g.; WIP, shared, published, archived)	[46]

3.0 METHODOLOGY

Preliminary validation with a group of BIM experts on BIM activities and capabilities was done, and a few items were removed, resulting in the final six BIM capabilities reported in Table 1. The validation process is important to ensure that each capability identified is exclusive to the current architectural field and are reflected in the native architectural practices as mentioned by Wong, Salleh, & Rahim [18].

A questionnaire was developed to fulfil the aim of this study, which is to investigate the extent of BIM capabilities in current architectural practices in Malaysia in different BIM stages. This study utilised BIM stages from the BIM framework derived from Succar's PoA and applied in BN EN ISO 19650, namely Stage 0, Stage 1, Stage 2, and Stage 3, to demarcate the level of BIM implementation in each architectural practice.

BIM stage 1 refers to object-based modelling where there is a use of 3D parametric modelling using authoring tools such as Revit, ArchiCAD and Tekla [12]. On the other hand, BIM stage 2 highlights the process of sharing object-based model and data between different disciplines through interoperable model exchange [30]. In BIM stage 2, incorporation of guidelines such as BS EN ISO 19650 standards results in establishment of Common Data Environment (CDE), BIM Execution Plan (BEP) and so forth [50]. BIM stage 3 involves network-based integration of the collaboration process of all project parties using cloud-based CDE. This results in synchronized information exchange between project members.

The quantitative method based on the survey technique was chosen to provide the general picture of the research problem, which is to learn about the extent of the current BIM capability in the architectural industry in Malaysia. This method has used random probability sampling technique to select a large number of respondents to represent the identified segment of population.

The survey questionnaire was distributed to 285 registered architectural firms in Klang Valley through online platforms. 51 questionnaires were received. After processing the data collected, only 38 valid responses were selected representing a 13.3% response rate. The low response rate was predicted due to the online survey method. It was mentioned by Fellows & Liu [48] that it is not unusual to get less than a 20% response rate using this method.

The data collected were tabulated and analysed using descriptive analysis to exhibit frequencies and patterns within the sample data. The measure of central tendency (mean value) was used to identify response points on the questionnaire scale [25]. In this research, the mean score was obtained to reflect the ranking of BIM activities in each BIM stage. Then, the Statistical Package for Software Science (SPSS) software was used to aid the data analysis process.

4.0 RESULTS AND DISCUSSION

The survey was used to discover the extent of the six BIM capabilities in the current architectural practices in Malaysia, as shown in Table 2. Respondents were categorised into different stages of BIM in the architectural practices, which are Stage 0, Stage 1, Stage 2, and Stage 3, based on their understanding and assumptions. The majority of the respondents representing architectural practices are in Stage 1 BIM implementation (36.8%), while the number of respondents who are working in Stage 2 and Stage 3 BIM implementation firms are similar (23.7%). In terms of experience, about 53% of respondents have worked using BIM for more than a year, and most of them are from Stage 1 BIM implementation firms. This indicates a relevant amount of knowledge to assess BIM activities performed in their respective organisations.

Current BIM Capabilities and BIM activities in Architectural Practices

Based on the results, six BIM Capabilities were analysed according to the frequency of BIM activities performed in the organisations. The entire range of mean reported for BIM Capability is between 1.92 to 3.40, suggesting a slight difference in value between each capability. It can be inferred that architectural firms have not yet developed BIM capabilities well in general terms.

C1: Design Authoring (M = 3.40, SD=1.2960) emerged as the most acquired capability by architectural firms. The most performed activities to acquire *C1* is reported to be *C1A1* (*Manipulate, navigate, and review the 3D BIM model created)*. This suggests that architectural firms are capable of manipulating, navigating, or reviewing the BIM model better than creating the BIM model itself from scratch using the parametric and intelligent information system BIM is supposed to have. This implies the outsourcing or employing external BIM consultants to produce 3D BIM models out of 2D drawings produced internally.

Additionally, *C1A6 (Use the 3D BIM Model for Detailed Modelling)* is ranked higher than other activities which may indicate that the architectural firms are still practising conventional practices where the application of BIM using 3D model is limited in producing detail drawing during the design development phase after the design is fixed. This is opposed to the suggested BIM practices where the 3D BIM model is used in all design process such as conceptual massing and planning [39] to incorporate inputs from other consultants and variety of analysis earlier in the design phase.

Findings revealed that the *C2: Design Coordination and Review (M = 3.20, SD=1.4072)* is one of the most acquired capabilities showing that the architectural firms have performed activities related to their project. It could be deduced that most construction firms used their BIM model to help relay their ideas to the clients and other consultants for better understanding. The results are expected because this capability is one of the main and basic capabilities needed before the construction practice could embark on developing other capabilities.

The relatively low mean value of *C3: Design Coordination and Review (M = 2.75, SD=1.2227)* is expected as coordination activities require the architectural firm to exercise interactions with different project consultants, while in some stages of BIM implementation, the adopters might not be ready to implement BIM in real projects yet and is still in the process of improving their internal capability. In other cases, other consultants' competency could affect the *C3* performance of architectural practices.

In order to perform good design coordination and review, the architectural firms will have to start on internal production of BIM deliverables for coordination purposes such as *C3A2 (Produce 3D base architecture model in LOD 300- LOD 400)* and *C3A3 (Produce a parametric modelling to allow consistent changes (using parameters) during the design coordination and review process)* before involving in actual coordination of the 3D BIM models. Thus, the result shows that both *C3A2* and *C3A3* are the highest performed activities compared to other activities under *C3* which require more participation of other project consultants in the real BIM project environment.

On the other hand, the least performed activity detected under *C3* set is *C3A6 (Participate in BIM e-submission (NBeS) for code compliance checking).* This has shown that most architectural practices were not involved yet with the code compliance application such as the National BIM e-Submission (NbeS) system. This might be because the system is still running in pilot project done through collaboration by CIDB and local authorities [49]. In addition, most of the requirements necessary to be included in the model information need a good and correct modelling technique from all consultants.

From the perspective of design coordination workflow by Leite [35], *C3: Design Coordination and Review (M = 2.75, SD=1.2227)* and *C5: Constructability Analysis (M = 3.15, SD=1.5385)* are closely related. Architectural practitioners will have to prepare the 3D base model to be coordinated internally (in *C3*) and later go through the clash detection process (in *C5*). Hence, the *C5* set of capabilities was supposed to be acquired when the architectural practices have developed *C3* well.

However, despite its immense importance, *C3* capability development is lower than *C5*. The high mean value of *C5* can be presumed to be the result of an inappropriate practice of the constructability analysis process in architectural practices. This is evidenced by high mean value for *C5A3* (*Develop construction documents that consist of 2D drawings (generated from 3D model) as deliverables before construction stage)* and *C5A4 (Develop construction documents that consist of technical documents and specifications (generated from 3D model) as deliverables before construction stage)* compared to other activities in C5. This is supported by Leite [35] which stated that the d141evelopment of BIM model up to LOD300 and clash detection activities are integral for the architectural practices to produce 2D drawings and documentations as deliverables before the construction began. Hence, it could be inferred that the architecture firms might be able to produce the deliverables stated but not up to the quality needed in the correct BIM procedure, thus explaining the reason behind the unexpected high mean values answered by the respondents.

Table 2 Descriptive analysis of BIM capabilities and BIM activities

Code	Mean	SD	Rank
C1: Design Authoring (M= 3.40, SD=1.2960)			
C1A1	3.71	1.3932	2
C1A2	3.76	1.4784	1
C1A3	3.10	1.5560	6
C1A4	3.24	1.5145	4
C1A5	3.18	1.4492	5
C1A6	3.42	1.4451	3
C2: Design Visualisation and Simulation (M= 3.20, SD=1.4072)			
C2A1	3.29	1.5406	1
C2A2	3.10	1.3909	2
C3: Design Coordination and Review (M= 2.75, SD=1.2227)			
C3A1	3.03	1.6189	3
C3A2	3.16	1.6028	2
C3A3	3.18	1.5220	1
C3A4	2.89	1.5732	4
C3A5	2.39	1.4433	5
C3A6	1.87	1.2557	6
C5: Constructability Analysis (M= 3.14, SD=1.5385)			
C5A1	3.03	1.6683	3
C5A2	2.97	1.6683	4
C5A3	3.34	1.5644	1
C5A4	3.24	1.5671	2
C6: Project Changes Management (M= 2.71, SD=1.2949)			
C6A1	3.11	1.5030	1
C6A2	2.13	1.4175	3
C6A3	2.89	1.5208	2
C7: Collaboration and Coordination (M= 2.85, SD=1.5883)			
C7A1	3.05	1.6266	3
C7A2	2.76	1.7620	1
C7A3	2.89	1.6892	2
C7A4	2.84	1.6196	5
C7A5	2.71	1.6259	4

C7: Collaboration and Coordination (M = 2.85, SD=1.5883) and *C6: Project Changes Management (M = 2.71, SD=1.2949)* appeared as the least acquired capabilities and are related in such that project changes management is more effective when the architectural practices have acquired *C7. C6* capability acquisition could be improvised using collaboration tools with certain features available for change management such as mark-up functions, file version tracking that could identify changes in different file versions, transmittal, and issue assignments to responsible parties.

The highest mean for BIM activities in this capability set is *C6A1 (Share updated model and clarify changes to other parties/ disciplines in a BIM project at the same time)* and followed by *C6A2 (Synchronise changes to all project team members automatically without redelivery of changed information).* The result may indicate that the architectural firms are still using the conventional method of delivering changes to other parties instead of using the collaboration tools for that purpose.

On the other hand, the architectural firms are proven to have used the collaboration tools through the highest-ranked activities performed under *C7*, which is *C7A2 (Use any cloud-based common data environment/server such as BIM 360, Buzzsaw, or WebEX)*. However, according to the results of other activities performed under *C7*, the usage of BIM collaboration tools might be because of the requirements given by the clients. This is because the tools were used only to share the 3D BIM models to other stakeholders and not for other potential purposes.

BIM Capabilities According to BIM Stages

The BIM capabilities are classified further based on the BIM stages category of each architectural firm, namely BIM Stage 1, BIM Stage 2, and BIM Stage 3, to assess the difference in capability acquisition based on their level of implementation.

As shown in Table 3, the architectural practices categorized under Stage 1 BIM implementation, the main capabilities developed were *C1: Design Authoring (M = 3.41, SD=1.0933)* followed by *C2: Design Visualisation and Simulation (M = 2.89, SD=1.0411)* with main values above 2.50. Other than that, the activities were performed quite poorly.

Table 3 BIM capability ranked in BIM Stage 1 Practices

No.	BIM Capabilities	Mean	SD	Rank
C1	Design Authoring	3.41	1.0933	1
C2	Design Visualisation and Simulation	2.89	1.0411	2
C5	Constructability Analysis	2.50	1.0423	3
C3	Design Coordination and Review	2.21	.8433	4
C6	Project Changes Management	2.05	.9595	5
C7	Collaboration and Coordination	1.84	1.0173	6

As reported in Table 4, the highest mean value is 4.25, while the lowest is 3.37. It shows generous appreciation in the frequency of activities done in architecture firms in this stage compared to previous stages. In Stage 2 BIM implementation, the architectural practices focused on developing *C5: Constructability Analysis (M = 4.25, SD=0.9520)* and *C7: Collaboration and Coordination (M = 3.89, SD=1.0682)* are compared to other types of capabilities. Compared to Stage 1 BIM implementation, *C2: Design Visualisation and Simulation (M = 3.67, SD=1.1726)* and *C3: Design Coordination and Review (M = 3.54, SD=0.8282)* capability acquisition have been increasing impressively.

For architectural practices that claimed to be in Stage 3 BIM implementation, Table 5 reveals that the highest mean value has increased compared to Stage 2 BIM implementation, which is 4.39, and the lowest mean value is 3.76, indicating a slightly higher volume of BIM activities done by the firms. However, it is unexpected that the highest mean score would be from *C2: Design Visualisation and Simulation (M = 4.39, SD=1.1118)* while still focusing on developing *C7: Collaboration and Coordination (M = 4.33, SD=1.2124)*. The development of *C5: Constructability Analysis (M = 4.25, SD=1.3863)* is found to be indifferent to the previous stage.

Other than that, *C3: Design Coordination and Review and C6: Project Changes Management* continue to be ranked lower than other capabilities by both Stage 2 and Stage 3 practices, and the mean values do not have any significant changes despite its immense importance for a smooth project delivery. Hence, these two capabilities should be developed more by current architectural practices in both stages for the project to reap real BIM benefits in terms of reducing project cost and time (51,52).

The results show capability acquisition based on different BIM stages in current practices and could be discussed further in comparison to the critical capability that the architectural practices should acquire in different studies.

Table 4 BIM capability ranked in BIM Stage 2 Practices

No.	BIM Capabilities	Mean	SD	Rank
C5	Constructability Analysis	4.25	.9520	1
C7	Collaboration and Coordination	3.89	1.0682	2
C1	Design Authoring	3.81	.6793	3
C2	Design Visualisation and Simulation	3.67	1.1726	4
C3	Design Coordination and Review	3.54	.8282	5
C6	Project Changes Management	3.37	.8731	6

Table 5 BIM capability ranked in BIM Stage 3 Practices

No.	BIM Capabilities	Mean	SD	Rank
C2	Design Visualisation and Simulation	4.39	1.1118	1
C7	Collaboration and Coordination	4.33	1.2124	2
C1	Design Authoring	4.33	.8700	3
C5	Constructability Analysis	4.25	1.3863	4
C6	Project Changes Management	3.89	1.0672	5
C3	Design Coordination and Review	3.76	.8978	6

5.0 CONCLUSION

This study identified current practices in terms of BIM activities and capabilities among architectural practices in Malaysia. The survey results show a total of six main BIM capabilities that were found significant to be developed by the architectural practices in Malaysia. They are design authoring, design visualisation and simulation, design coordination and simulation, design coordination and review, constructability analysis, project changes management, and collaboration and coordination. The capabilities could be acquired by performing different types of BIM activities related to the architectural scope of work. The results also provide different emphasis on capability development at different stages of BIM implementation by the current practices. From the focus pattern presented, the capabilities that have been developed mostly by the architecture firm can be recognised by design authoring, design visualisation and simulation, and constructability analysis.

The understanding of different BIM activities that could lead to different capability acquisition will help the organisations to re-focus and prioritise specific activities to be performed to move forward throughout different BIM stages. This should be done strategically by assessing their competitive advantages and organisation's resources Further research could be done as an extension to this study by proposing critical BIM capability that should be developed by architectural practices in Malaysia for a more efficient BIM implementation process. A study could also be conducted focusing on different competency levels regarding BIM capability enablers such as technology, process, policy, people, and so on. This is to provide further guidelines for architectural practices on what to invest and spend on to develop certain capabilities needed based on the critical BIM capability framework.

Acknowledgement

The authors would like to acknowledge the support of the experts from which the results and discussion concerning the BIM capabilities and the activities were developed and all the questionnaire respondents.

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