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Readiness in Implementing Heritage Building Information Modelling (HBIM) Among Conservation Practitioners in Malaysia

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Abstract

Heritage Building Information Modelling (HBIM) is receiving significant attention in the architectural heritage field due to its ability to support the management of heritage conservation processes worldwide. It is a multidisciplinary technique and useful for managing and recording historical buildings. This research study explores the readiness of conservation practitioners to implement HBIM in documenting and conserving architectural heritage in Malaysia. Data on heritage conservation in Malaysia has been collected from related bodies. The present study employed a combination of questionnaire surveys and literature review as its methodology. The result reveals that in terms of practitioners' knowledge or awareness, it can be concluded that their understanding of HBIM remains low. Regarding organisation readiness, it can be determined that their readiness to adopt HBIM is extremely low. In the context of challenges, it is possible to infer that their readiness is poor based on their challenges. Therefore, this research may prove the readiness level among conservation practitioners to adopt this technology. This study is also crucial in giving conservation practitioners strategies to improve their readiness to implement HBIM in future conservation works.

1.0 INTRODUCTION

Building Information Modelling (BIM) in the Malaysian context is defined as, "A modelling technology and associated set of processes to produce, communicate, analyse and use of digital information models throughout construction project life cycle" (CIDB, 2017). Correspondingly, Heritage BIM (HBIM), often called Historic BIM, is a BIM branch aiming to precisely model the geometry and data associated with historical structures (Maurice, McGovern, & Pavia, 2009).

Notably, BIM adoption in Malaysia is still in the beginning and is mostly concentrated in a few types of construction, especially for new buildings. Despite its benefits in other areas of the building industry, it is still not widely used in conservation projects. BIM, an emerging technology, has applications in both the construction of buildings and the management of buildings from pre-construction to post-construction.

Meanwhile, Historic Building Information Modeling (HBIM) is a digital model that allows conservationists to simulate restoration techniques and evaluate their impact on a building's structural stability and historical authenticity. It facilitates collaboration among international experts, ensuring that traditional knowledge and modern practices are converged effectively. The integration of HBIM leads to successful restoration processes, as it informs decision-making, minimizes risks, and enhances cost-efficiency. The cathedral's digital twin serves as an ongoing management tool, supporting future preservation initiatives and educational endeavors. Research by Dore and Murphy (2017) and Volk et al. (2014) highlights the benefits of BIM for facility management and historic building conservation, highlighting improved data accessibility and interoperability. HBIM is essential in the global quest to preserve cultural heritage, providing a framework for sustainable, informed, and collaborative restoration endeavors.

A historic or heritage building is a valued national asset, and if its current structure is gone nothing can be maintained. Accuracy is one of the most important aspects of heritage building preservation. Therefore, HBIM may be implemented for construction and maintenance work and will provide more accurate projects when it is integrated into conservation projects.

Most of the data that are collected during building preservation works are managed conventionally. Incomplete information during the restoration construction phase can cause communication issues throughout the design and construction stages, making it challenging to ensure the quality of the restoration and resulting in the partial completion of conservation activities.

2.0 LITERATURE REVIEW

2.1 Definition of BIM and HBIM

BIM encompasses the entire process of creating and maintaining information for a constructed object. BIM integrates structured, multi-disciplinary data to create a digital representation of an asset's lifecycle, from planning and design to building and operations, utilising an intelligent model and a cloud platform (What Is BIM | Building Information Modeling | Autodesk, n.d.).

Murphy et al. (2017) described HBIM as a BIM extension for the management and protection of architectural heritage both physical and in terms of knowledge. It is the digital recording of historical structures by remote sensing (laser scanning, digital photogrammetry) or a mix of digital surveying and manual procedures. The gathered survey data is subsequently analysed using BIM software platforms, enhancing data organisation and adding intelligence.

2.2 Relation Between BIM and HBIM

BIM and HBIM are related concepts that involve the use of digital technologies to create and manage information about buildings. While BIM applies to all types of construction projects, HBIM focuses on the specific needs of historic preservation and conservation. However, both BIM and HBIM aim to improve efficiency, collaboration, and decision-making in the construction and management of buildings, with HBIM emphasising the unique requirements of heritage structures.

Building Information Modeling (BIM) is a crucial tool in the heritage sector, facilities management, and restoration planning. It enables detailed documentation and analysis of heritage assets, preserving national identity and historical legacy. BIM also plays a vital role in facilities management, promoting interoperability

and seamless data exchange. It allows for efficient handling of information through standardized frameworks, optimizing maintenance schedules, resource allocation, and operational efficiency.

In restoration planning, BIM allows for modeling and simulation of restorative techniques, predicting potential challenges and outcomes. This anticipatory approach enhances the effectiveness of restoration techniques. The integration of BIM with FM tasks ensures a cohesive strategy that aligns technological advancements with traditional restoration methodologies.

BIM acts as a bridge between preserving heritage buildings' authenticity and adapting them to contemporary standards. This amalgamation allows for a seamless transition between conservation efforts and modernism in building management, ensuring heritage buildings thrive functionally.

In summary, the integration of BIM in heritage sectors, facilities management, and restoration planning creates a comprehensive system that enhances the efficiency, accuracy, and sustainability of building conservation and management practices. This synergy promotes the alignment of historical preservation with modern technological advancement, safeguarding cultural heritage while enabling functional adaptability. The relation is summarised in Figure 1 below.

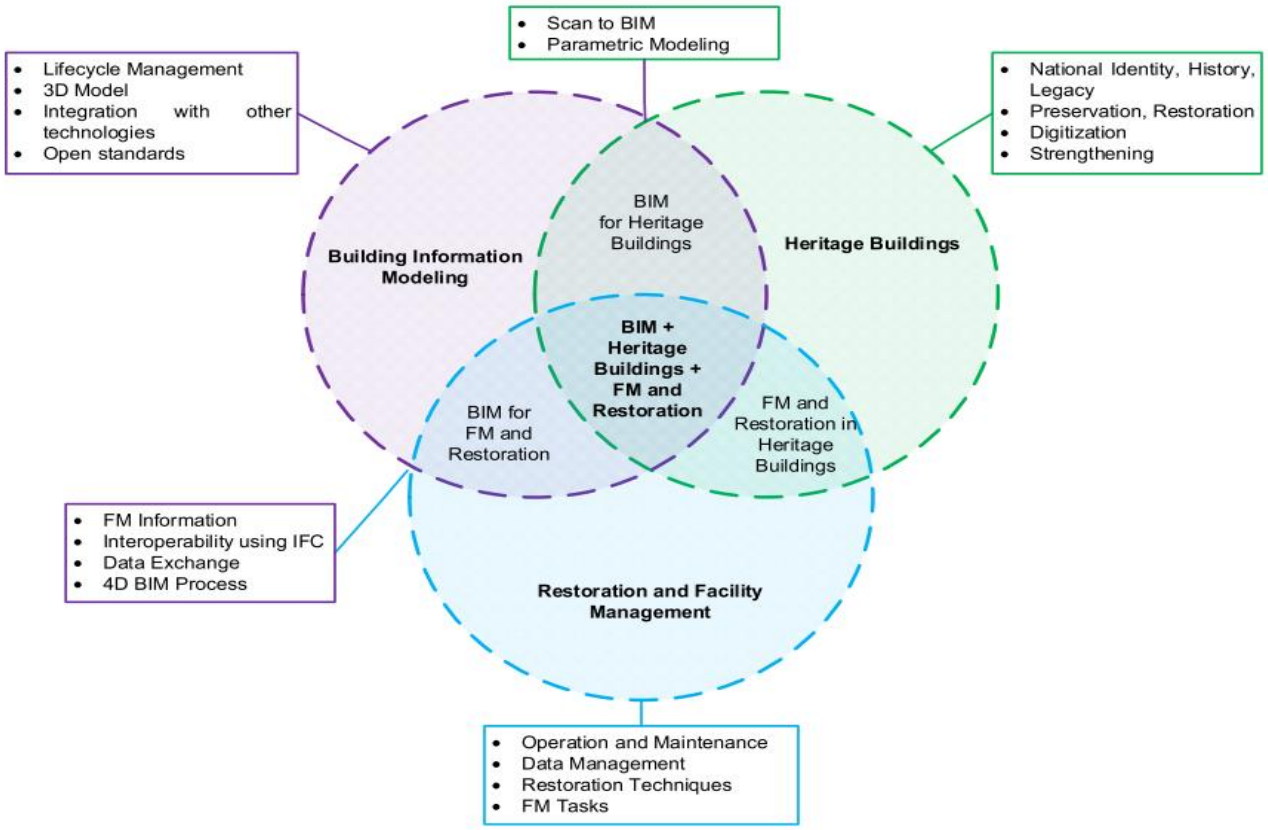

Figure 1. Existing Studies About BIM, Its Application in the Heritage Sectors, FM and Restoration Planning, and Their Integration. Source: (Khan et al., 2022)

2.3 HBIM Applications in Conservation Works

Heritage building documentation is fundamental for safeguarding our cultural heritage, enabling informed conservation decisions, and ensuring that the historical significance of buildings is preserved for future generations Through 3D laser scanning and photogrammetry, HBIM enables accurate and thorough recording of historic structures. This captured data gives a complete picture of the actual state of the structure, including architectural aspects, materials, and degradation.

Besides that, HBIM is important in documenting the current condition of the building through continuous assessment. Building Conditions Assessment (BCA) is a crucial phase in the renovation of an existing building as well as within a BIM workflow, before deciding on the appropriate interventions. As a result, it is vital to pick instruments and techniques to achieve the goals of collecting accurate information. To identify masonry

textures, deterioration patterns, damage, and vulnerabilities of materials and structural sections, the BCA compares information that is acquired during early in-situ inspections (Bruno et al., 2018).

Furthermore, HBIM plays major role in preservation planning, By offering a digital platform for specialists to interact and make educated decisions, HBIM supports the formulation of preservation strategies (Adami et al., 2018). It enables the stakeholders to investigate alternative preservation options and analyse the effects of various interventions.

HBIM also aids conservation and restoration design processes by allowing architects and engineers to digitally test proposed solutions. It aids in determining how changes may influence the structure and look of the building, enabling a careful and well-informed approach to the restoration (Murphy et al., 2009).

Lastly, the HBIM application for heritage buildings may generate 3D parametric models and gather semantic data; nevertheless, advancements in current research are required to help the restoration and FM procedures (Khan et al., 2022).

2.4 Potential Benefits Of HBIM

HBIM benefitted the industry by allowing accurate documentation and visualisation of heritage building to enable decision making, improve collaboration and planning for maintenance. HBIM offers incredibly realistic and thorough 3D representations of old buildings, complete with their unique architectural details. Stakeholders can see the historical components of the building due to this digital record, which helps them comprehend its importance and condition (Khan et al., 2022). With BIM, building numbers and quality may be more accurately recorded compared to traditional design and documentation techniques (Krygiel & Nies, 2008).

Making decisions is made easier by having a computerised image of the ancient structure. Stakeholders may investigate different preservation methods, evaluate their effects, and select the best strategy, guaranteeing a more effective and economical preservation procedure. These advantages increase the efficiency of a BIM project. By sketching building parts only once in the project instead of a drawing plan, elevation, and section, time can be saved to focus on other design challenges (Krygiel & Nies, 2008). HBIM encourages cooperation among various stakeholders, including community members, architects, engineers, historians, and conservators. Stakeholders may collaborate easily, exchange information, and jointly reach decisions using a shared digital model (Krygiel & Nies, 2008).

HBIM helps with the continuing facilities management and maintenance of historic buildings. The structure's life can be extended, and long-term maintenance expenses can be decreased by keeping a digital record of the building's conditions (Counsell & Taylor, 2017). Traditional paper-based records are at risk of deterioration over time, whereas digital HBIM models provide future generations with durable, easily accessible archives of historical and architectural data.

2.5 Challenges in the Adoption of HBIM

2.5.1 Data Collection and Accuracy

Among the challenges faced in adopting HBIM are the ability of the data for collection and its accuracy, the complexity of heritage building itself and the cost and expertise in the field. Accurate data collection for an HBIM model can be difficult, especially for older and historic structures where documents may be inadequate or missing. Thorough on-site surveys, historic record searches, and laser scanning are all required, which may be time-consuming and costly.

In the case of cultural heritage objects, things are more complex as cultural heritage monuments are mainly made of components and materials whose geometry and characteristics are not representative of typical software libraries (Logothetis et al., 2015). HBIM implementation needs specialised knowledge and abilities in historical preservation, BIM modelling, and data analysis. Hiring qualified individuals and investing in modern technology might be prohibitively expensive, especially for smaller organisations or communities. According to Ismail *et al*., (2021), only major companies can afford the pricey technology since implementing BIM requires a significant financial commitment.

3.0 METHODOLOGY

Previous literature has been studied to collect information about BIM and HBIM, such as their history and definition, advantages, and the goals of HBIM application in conservation projects. Books, journal articles, papers from international conferences, and internet items have been examined. The questions for the survey were designed based on the findings and to achieve the aim of the study. The framework from the literature above served as guide for the questionnaire survey.

This study uses a quantitative research technique. As the number of conservation practitioners is limited (only 50 registered conservators listed in JWN site), the study included respondents selected from a list of registered conservators or other conservation practitioners in both the public and private sectors. The structured questionnaires are designed to consider the unique perspectives and responsibilities of the respondents. Fifty respondents who are BIM users or familiar with BIM have been approached. A total of 30 responses were returned, with a success rate of 60%. A structured questionnaire survey has been given to them using Google Forms. The questionnaire was divided into four (4) parts. The first part is demographic information, the second part is on knowledge and awareness, the third part is on the readiness and benefits of HBIM, and the last part is on the HBIM challenges. The questionnaire mostly uses the Likert Scale of five ordinal measures from one (1) to five (5).

4.0 RESULTS AND DISCUSSIONS

4.1 Knowledge/Awareness Data

Figure 2 shows that 16.67% of the respondents are very knowledgeable about HBIM, 46.67% are moderately knowledgeable, 23.33% are somewhat knowledgeable and 13.33% are not knowledgeable.

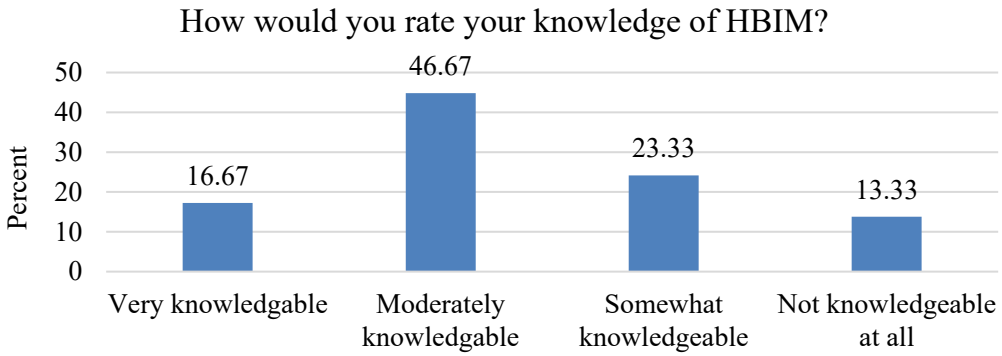

Figure 2. Respondent's Knowledge of HBIM

From Table 1, although 86.7% of the respondents have heard of HBIM, only 10.0% have been involved in HBIM projects while less than half (46.7%) are aware of HBIM projects being related to historic building conservation.

Table 1. Respondents' Knowledge/Awareness of HBIM

	Yes	No
Have you heard of Heritage Building Information Modelling (HBIM) before taking this survey?	86.7%	13.3%
Have you previously worked on or been involved in any HBIM projects?	10.0%	90.0%
Are you aware of any specific HBIM projects related to historic building conservation in your region or field of work?	46.7%	53.3%

Table 2 summarises the level of importance of resources in increasing HBIM knowledge. The most important resource is Educational Workshops and Training where 96.7% of the respondents have agreed that it is very important. However, only 56.7% believed that grants and funding are significant in increasing their awareness of this issue.

Table 2. Importance of Resources or Information in Increasing Knowledge/Awareness of HBIM for Building Conservation.

		Sub Table N %	Mean	Standard Deviation
Educational Workshops and Training	Very Important	96.7%		
	Important	0.0%		
	Moderately Important	3.3%		
	Slightly Important	0.0%		
	Not Important	0.0%		
	Descriptive Statistics		**4.93**	**.37**
Case Studies showcasing how HBIM has been effectively used in heritage building projects	Very Important	76.7%		
	Important	23.3%		
	Moderately Important	0.0%		
	Slightly Important	0.0%		
	Not Important	0.0%		
	Descriptive Statistics		**4.93**	**.37**
Information and guidelines provided by heritage conservation agencies	Very Important	70.0%		
	Important	30.0%		
	Moderately Important	0.0%		
	Slightly Important	0.0%		
	Not Important	0.0%		
	Descriptive Statistics		**4.70**	**.47**
Collaborate on projects or research efforts with HBIM-experienced institutions or experts	Very Important	73.3%		
	Important	23.3%		
	Moderately Important	3.3%		
	Slightly Important	0.0%		
	Not Important	0.0%		
	Descriptive Statistics		**4.70**	**.53**
Accessible Software and Tools	Very Important	83.3%		
	Important	13.3%		
	Moderately Important	0.0%		
	Slightly Important	3.3%		
	Not Important	0.0%		
	Descriptive Statistics		**4.77**	**.63**
Grants and funding opportunities that support the implementation of HBIM in heritage building projects	Very Important	56.7%		
	Important	40.0%		
	Moderately Important	3.3%		
	Slightly Important	0.0%		
	Not Important	0.0%		
	Descriptive Statistics		**4.53**	**.57**

4.2 Readiness and Benefit

In Figure 3, 76.67% of the respondents have said that they are very interested in learning more about HBIM. However, based on Figure 4, 63.33% of them have never participated in any HBIM training, workshops, or seminars.

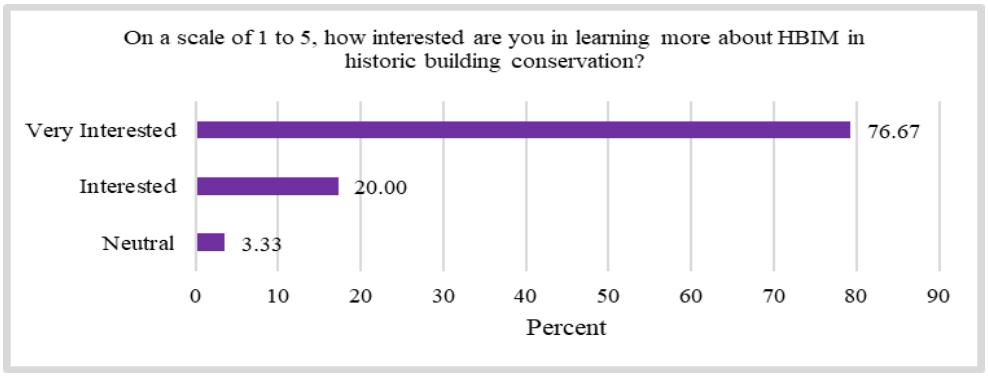

Figure 3. Level of Interest in Learning More About HBIM

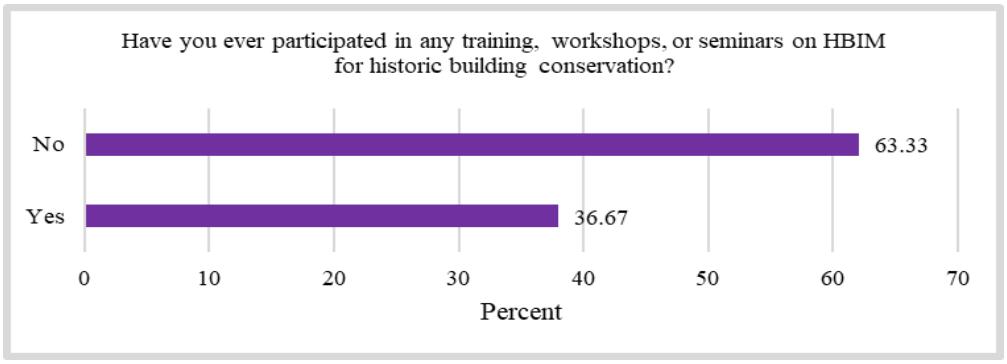

Figure 4. Participation in Training, Workshops or Seminars About HBIM

According to Table 3, in terms of organisations' readiness, none of the respondents are implementing HBIM in their conservation projects. In addition, 56.67% of the respondents' organisations do not have a clear strategy for implementing HBIM in their projects. The result also shows that 46.67% of respondents have said that there are no dedicated personnel or teams in the organisations responsible for HBIM implementation. 56.67% of the organisations have access to HBIM hardware and software compared to 40.00% who do not. It also shows that 60.00% of organisations' teams still have not received any training in HBIM, and only 20.00% have already received HBIM training.

Table 3. Organisation Readiness in Increasing Knowledge/Awareness of HBIM for Building Conservation

		Percentage %
Implementation of HBIM in Organisations' Conservation Project	Yes	0.00%
	No	100.00%
	In Progress	0.00%
Organisations' Strategy for Implementing HBIM in Their Projects	Yes	16.66%
	No	56.67%
	In Progress	26.67%
Dedicated Personnel or Teams Responsible for HBIM Implementation	Yes	40.00%
	No	46.67%
	In Progress	13.33%
Organisations' Accessible to HBIM Hardware and Software	Yes	56.67%
	No	40.00%
	In Progress	3.33%
Organisations' Training in HBIM	Yes	20.00%
	No	60.00%
	In Progress	20.00%

As in Table 4 below, 90.0% of the respondents fully agree that HBIM can enhance documentation and record-keeping. 80.0% fully agree it improves conservation planning and decision-making, and 86.7% fully agree it can produce comprehensive documentation for conservation work. In terms of better structural analysis and monitoring, 56.7% are in total agreement.

For the preservation of historical details and materials, cost saving in long-term maintenance, increased effectiveness in project management, and increased public engagement, 60.0% of the respondents fully agree with those benefits. Meanwhile, only 43.3% fully agree with the accuracy of the project cost estimation, and only 40.0% of the respondents fully agree that HBIM can expedite project completion.

Table 4. Potential Benefits of Using HBIM in the Conservation of Heritage Buildings

		Sub Table N %	Mean	Standard Deviation
Enhance documentation and record-keeping	Totally Agree	90.0%		
	Agree	10.0%		
	Neutral	0.0%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.90**	**.31**
Improve conservation planning and decision-making	Totally Agree	80.0%		
	Agree	20.0%		
	Neutral	0.0%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.80**	**.41**
Comprehensive documentation for conservation work	Totally Agree	86.7%		
	Agree	13.3%		
	Neutral	0.0%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.87**	**.35**
Better structural analysis and monitoring	Totally Agree	56.7%		
	Agree	33.3%		
	Neutral	10.3%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.47**	**.68**
Preservation of historical details and materials	Totally Agree	60.0%		
	Agree	30.0%		
	Neutral	10.0%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.50**	**.68**
Cost savings in long-term maintenance	Totally Agree	63.3%		
	Agree	30.0%		
	Neutral	6.7%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.57**	**.63**
Accurate project cost estimation	Totally Agree	43.3%		
	Agree	33.3%		
	Neutral	23.4%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.20**	**.81**
Increase public engagement and education	Totally Agree	60.0%		
	Agree	40.0%		
	Neutral	0.0%		
	Disagree	0.0%		

	Totally Disagree	0.0%		
	Descriptive Statistics		**4.60**	**.50**
Faster project completion	Totally Agree	40.0%		
	Agree	23.3%		
	Neutral	30.0%		
	Disagree	6.7%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**3.97**	**1.00**
Increase effectiveness in project management	Totally Agree	63.3%		
	Agree	33.3%		
	Neutral	3.4%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.60**	**.56**

Figure 5 indicates that 53.33% of the respondents have reported feeling neutral about implementing HBIM in their conservation work, 20.00% feel ready to do so, 23.33% are completely ready, and 3.34% are not prepared to do so.

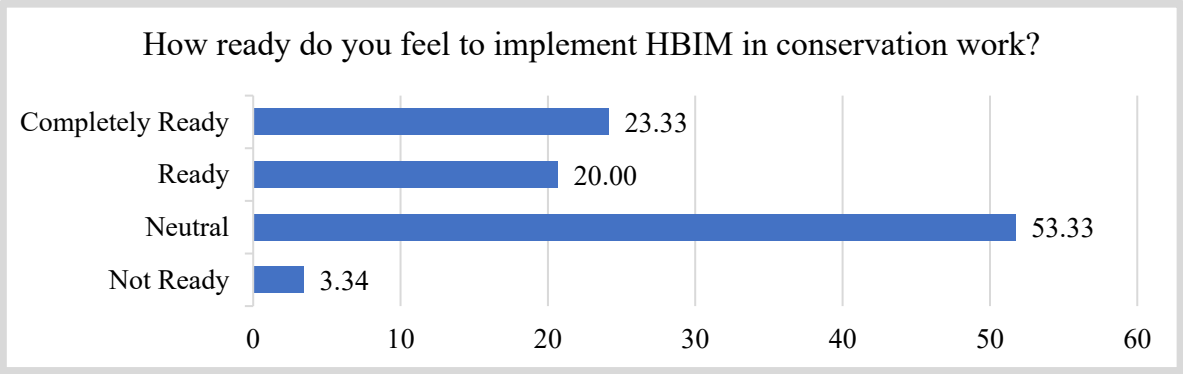

Figure 5. Readiness in implementing HBIM in Conservation Work

4.3 Challenges

Most of the respondents agreed that the biggest challenges in adopting HBIM are the need for high technology (80.0%), lack of technical skills (70.0%), high cost of running the technology (60.0%), and a lack of knowledge and awareness (53.3%). There are various opinions on two items. which are 'refuse to learn among the heritage practitioners' and 'no support from any related bodies.'

Table 5. Challenges of Using HBIM in the Conservation of Heritage Buildings

		Subtable N %	Mean	Standard Deviation
Lack of technical skills	Totally Agree	70.0%		
	Agree	26.7%		
	Neutral	3.3%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.67**	**.55**
Lack of HBIM knowledge and awareness	Totally Agree	53.3%		
	Agree	40.0%		
	Neutral	6.7%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.47**	**.63**
	Totally Agree	60.0%		
	Agree	36.7%		

High cost for running the technology	Neutral	3.3%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.57**	**.57**
Need for high technology	Totally Agree	80.0%		
	Agree	13.3%		
	Neutral	6.7%		
	Disagree	0.0%		
	Totally Disagree	0.0%		
	Descriptive Statistics		**4.73**	**.58**
Refuse to learn among the heritage practitioners	Totally Agree	10.0%		
	Agree	26.7%		
	Neutral	23.3%		
	Disagree	6.7%		
	Totally Disagree	33.3%		
	Descriptive Statistics		**2.73**	**1.44**
No support from any related bodies	Totally Agree	23.3%		
	Agree	33.3%		
	Neutral	30.0%		
	Disagree	3.4%		
	Totally Disagree	10.0%		
	Descriptive Statistics		**3.57**	**1.19**

Figure 6 reveals that 13.33% of the organisations are highly committed to adopt long-term use of HBIM, while 40.00% are moderately committed, 30.00% are somewhat committed and 16.67% are not committed at all.

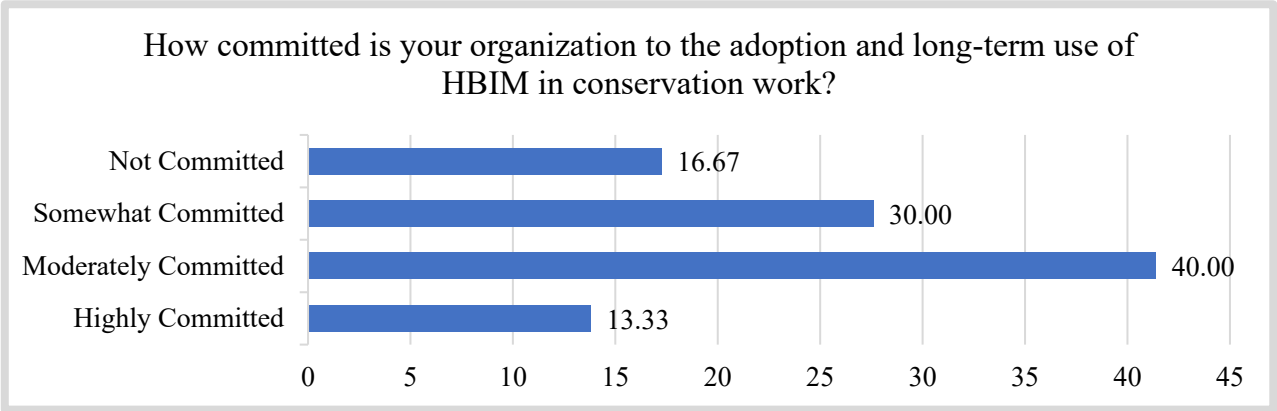

Figure 6. Level of Commitment in Organisations to Adopt HBIM in Conservation Work

The discussion will concentrate on two issues based on this research's objectives. The first issue concerns the current level of readiness of the respondents to implement HBIM in their conservation work. This will be based on their knowledge or awareness, the organisation's preparedness, understanding of the benefits and their perception of the level of importance of resources to increase HBIM knowledge. The second issue will relate to the challenges that obstruct their readiness to implement HBIM.

4.4 Current Level of Readiness

According to the data analysis in Table 1, while most respondents had heard of HBIM, only a handful have participated in HBIM initiatives, and less than half are aware of HBIM projects connected to historic building conservation. Most respondents claimed to have a modest level of knowledge or awareness of HBIM, as seen in Figure 2. This data is corroborated by previous research that has claimed that the obstacles to implementing BIM in Malaysia include a lack of BIM knowledge, the expense, a lack of BIM awareness, and the need to transition from traditional approaches. (Othman et al., 2021).

All the respondents understand the relevance of resources in expanding HBIM knowledge and awareness, as indicated in Table 2. Education seminars and training are seen to be the most crucial factors in increasing their knowledge and awareness. This finding is reinforced by Manzoor et al.'s (2021), research which indicated that workshops, lectures, and conference events are the most effective strategies for raising public knowledge of BIM.

Nevertheless, although the respondents realise the importance of workshops and training in raising their knowledge, their involvement in training and workshops remains low, as seen in Figure 4. This occurred because the organisations had yet to utilise HBIM in their projects.

It was also discovered that their preparedness to deploy HBIM remains poor, as evidenced by the results of the organisations' HBIM implementation strategies, as shown in Figure 5. Table 3 shows that the overall number of specialised people remains low. However, the number of organisations with access to HBIM hardware and software is relatively significant. It is also determined that their preparedness is low, as seen by the lack of HBIM training.

Table 4 shows respondents are highly aware of the benefits of utilising HBIM. This data is further backed by the Malaysia Building Information Modelling (BIM) Report 2021, which states that more than 90% of respondents (2016-2021) believe that BIM could give good advantages for project adoption since it meets time, cost, and quality requirements.

4.5 Challenges that Obstruct the Readiness

According to the data in Table 5, it is concluded that the primary challenges that they face are the need for high technology, the high cost of running the technology, the lack of HBIM knowledge, and the lack of technical skills. This data is supported by the data from the Malaysia Building Information Modelling (BIM) Report 2021, which has listed the high cost of software, technology, and training with a lack of BIM knowledge as the top-ranking challenges for adopting BIM from 2016 to 2021. According to Gamil and Rahman (2019), a lack of BIM knowledge is one of the most significant challenges to BIM adoption.

The extra challenge that organisations have in terms of financial resources to facilitate the implementation of HBIM. One of the biggest obstacles to BIM adoption worldwide is the cost, which includes training, hardware, and software. Since 2016, the CIDB has provided funding and subsidies to support the use and training of BIM software, especially for novice users (CIDB, 2016).

According to Malaysia BIM Report 2021, the respondents agree on their organisation's preparedness to implement BIM. According to the data, 74% of the respondents believe their organisation is prepared to use BIM in 2019. However, that figure fell to 58% in 2021.

Figure 7 conclude the barriers of implementation HBIM in Malaysia based on the findings that could be themed into limited expertise, resource availability, inadequate training and strategic planning.

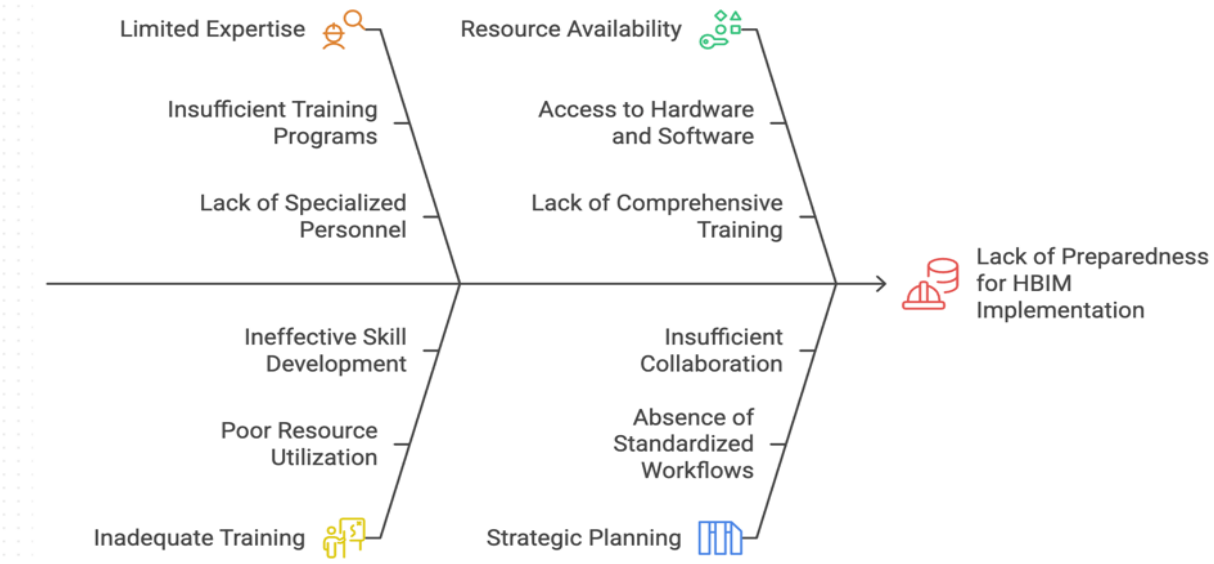

Figure 7. Challenges to HBIM Adoption in Malaysia

5.0 CONCLUSIONS

The study indicates that the practitioners' expertise of HBIM in Malaysia is notably deficient. They possess a comprehensive awareness of the significance and benefits of HBIM. Nonetheless, they seek to enhance their knowledge of HBIM and assert that training and seminars are crucial for broadening their skills. The assessment of organizational readiness indicates that their preparedness to implement HBIM is markedly deficient. The sole preparedness is contingent upon the organization's accessibility to HBIM equipment and software. In light of the obstacles faced, one can deduce that their preparedness is inadequate, notably with technical skills, knowledge deficits, financial constraints, and the necessary technology to operate the HBIM. The extent of an organization's preparedness to implement HBIM dictates its level of readiness.

Malaysia's building conservation organizations exhibit low readiness for HBIM owing to insufficient knowledge and awareness, inadequate financial incentives, lack of staff training, and minimal investment in BIM hardware or software. Formulating effective tactics and fostering awareness in HBIM implementation necessitates a blend of educational, communicative, and organizational methodologies. By using these development tactics, organizations can adopt a more comprehensive approach to enhancing awareness of HBIM implementation.

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