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# Implementation of Building Information Modelling (BIM) for the Operation and Maintenance (O&M) Phase of the Building Life Cycle in Malaysia

**Tan Chin Keng[1]*, Fierra Hailly Fadhaililamal[1]**

[1] *Department of Quantity Surveying, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 53100 Jalan Gombak, Kuala Lumpur, MALAYSIA*

*Corresponding Author: tckeng@iium.edu.my
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**Abstract**

Facilities Management (FM) plays a pivotal role in the operation and maintenance (O&M) phase of a building's life cycle. Despite various data management systems available for building maintenance, manual processes that deal with scattered and unformatted data still dominate. Building Information Modelling (BIM), a digital method introduced in the construction sector, has demonstrated its potential to enhance efficiency throughout a building's life cycle. However, its full potential in revolutionizing facilities management during the O&M phase remains largely unexplored and minimally implemented in Malaysia. This study has three objectives: to examine the implementation of BIM for the O&M phase, identify barriers to the implementation, and propose strategies to improve its implementation. Data was collected through questionnaires. The findings reveal that BIM adoption is in its early stages, with limited projects related to BIM. Critical barriers to implement BIM include the high-cost investment, lack of technical expertise, complex facility information, lack of preparation of materials and equipment by academic institutions, and unclear workflows within organisations. The study recommends key strategies such as comprehensive training, BIM education to reduce technical issues related to files and systems, secured funding, collaboration among FM stakeholders, and clearly defined objectives. These findings highlight the barriers the current FM practice faces and provide a roadmap for implementing BIM for the O&M phase of the building life cycle in Malaysia.

## 1. Introduction

Facilities Management (FM) plays a pivotal role during the operation and maintenance (O&M) phase of a building's life cycle, encompassing various disciplines such as maintenance, space management, asset management, catering, and cleaning (Noor & Pitt, 2010). However, despite its critical role, the traditional manual systems used in processing and managing building maintenance data may lead to inefficiencies and inadequate decision-making support (Bortolini et al., 2017). This inadequacy in data handling has urged innovation in integrating Building Information Modelling (BIM) into FM, offering enhanced efficiency and effectiveness during the O&M phase of a building's life cycle.

Technological advancements, including BIM, have revolutionised the construction industry by providing a digital platform for collaborative design, construction, and FM data management (Tezel et al., 2021). Unlike other emerging technologies, BIM offers a comprehensive solution for coordinating building information throughout the life cycle, thus serving as a valuable shared knowledge resource for facilities managers (Becerik-Gerber et al., 2012). By storing essential data electronically, BIM eliminates traditional paper documentation, making essential information accessible with just a click (Becerik-Gerber et al., 2012). This integration of BIM within FM holds significant promise for cost savings, increased efficiency, sustainability, and overall improved management of building assets (Azhar, 2011). According to Pan et al. (2023), the integration of BIM and AI can demonstrate newly added value in handling construction projects with inherent complexity and uncertainty. Zhou et al. (2024) highlighted that by guiding construction through BIM models, utilizing a BIM+GIS-based management cloud platform system, and employing VR safety briefings, the project effectively reduces the difficulty of communication and coordination in project management, shortens the project measurement cycle, improves on-site work efficiency, and ensures comprehensive control and safety management.

Cao et al. (2022) argued that as a multi-function method, Building Information Modeling (BIM) can assist construction organizations in improving their project's quality, optimize collaboration efficiency, and reduce construction periods and expenditure. Given the distinguished contributions of BIM utilization, there is a trend that BIM has significant potential to be utilized in the construction phase of green buildings. Van et al. (2023) found that BIM-related project factors and BIM-related technological factors also had a significant impact on project performance. Farouk et al. (2023) emphasized that implementing building information modeling (BIM) in construction projects can provide team members with an effective collaboration process. Therefore, organizations are implementing BIM to acquire the benefits. Pinti et al. (2022) stated that facilities management is an area that benefits the most from BIM, yet it is the least developed area regarding implementation. Wijeratne et al. (2023) proposed that BIM related tools and processors could be integrated to successfully implement BIM enabled asset management. The knowledge can be potentially useful for planning or implementing BIM enabled asset management systems.

However, in Malaysia, despite the potential of BIM to revolutionise facilities management, its implementation in the O&M phase remains minimal and underexplored. (Ariffin et al., 2021). Hence, this paper aims to explore strategies to enhance the implementation of Building Information Modelling (BIM) for the Operation and Maintenance (O&M) phase of the building life cycle in Malaysia. This study is structured into six (6) segments. Section 1 serves as an introduction, outlining the subject matter and the study's objectives. Section 2 presents a comprehensive review of the existing literature. Section 3 outlines the methodology employed for conducting the study. Section 4 delves into the presentation and discussion of the study's findings. Lastly, Section 6 encompasses the conclusion and offers recommendations for future research.

## 2. Literature Review

### 2.1 Operation and Maintenance Phase of Building Life Cycle (Facilities Management)

Facilities management (FM) is a combination of building design and management knowledge in the context of daily use (Leaman, 1992). It includes several activities, such as maintenance, administration, and financial management. The operation and maintenance (O&M) phase of a building's life cycle, often referred to as facilities management (FM), is a crucial component within the building's life cycle. This phase encompasses the coordination of physical space, personnel, and organisational processes to ensure a safe and functional environment for occupants, aligning with the original design intentions (Zawawi et al., 2016). Notably, O&M represents the most time-consuming and costly stage in a building's life cycle, demanding various actions to optimize performance, reduce operational expenses, and mitigate environmental impacts (Chen & Tang, 2019). Ultimately, the effective administration of facilities during the O&M phase holds the key to the success of an organisation, preserving a building's appearance and functionality, and ensuring optimal performance over its life cycle.

### 2.2 Building Information Modelling (BIM)

Building Information Modelling (BIM) is a multifaceted concept central to the planning, design, construction, and operation of buildings (NIBS, 2008, cited in Afzal, 2021). Furthermore, Succar (2010) characterizes BIM as an integrated process that harnesses a standardized, machine-readable information model to facilitate all phases of a building's life cycle. BIM serves as a collaborative platform for architects, contractors, designers, surveyors, and owners to share standardised information (Azhar, 2011). Hence, BIM affords comprehensive simulations of a building's life cycle, from inception to facility operation.

### 2.3 Building Information Modelling Implementation in the Operation and Maintenance Phase of Building Life Cycle

The implementation of Building Information Modelling (BIM) for the operation and maintenance (O&M) phase of a building's life cycle holds significant promise (Azhar, 2011). According to Kreider and Messner (2013), BIM-FM integration involves the comprehensive use of BIM throughout the building's life cycle to achieve specific objectives. Kassem et al. (2015) emphasise the visual presentation of maintenance-related data through BIM can enhance stakeholders' understanding of a building's status. Furthermore, BIM's transition from manual information exchange to real-time digital processes represents a pivotal advantage (Kassem et al., 2015), as it unifies stakeholders' responsibilities and functions on a single platform throughout the building's life cycle. However, despite the potential of BIM-FM integration, its implementation during the O&M phase remains relatively low, especially in Malaysia (Musarat et al., 2023).

## 2.4 Barriers to the Implementation of Building Information Modelling for the Operation and Maintenance Phase of Building Life Cycle

Several barriers to implementing BIM during the O&M phase of the building life cycle have been highlighted and this study categorised the barriers into technical, organisational, and legal barriers.

For technical barriers, BIM faces issues related to interoperability, making it challenging for facilities managers to seamlessly integrate BIM with other FM software (Musarat et al., 2023). The Industry Foundation Classes (IFC) format intends to facilitate data integration but is hindered by complex data structures, complicating data extraction (Musarat et al., 2023). The absence of data standardization among FM software further worsens interoperability issues (Goedert & Meadati, 2008). Moreover, the high complexity of managing facility information within BIM software arises from the various files and formats generated during design and construction (Irizarry et al., 2014). Merging these various data sources into a BIM model, which requires continuous updates, can lead to inaccuracies, data duplication, and accessibility issues, impacting BIM's accuracy and utility.

Organisational barriers encompass people, culture, and cost-related issues. The need for specialised technical skills for BIM model maintenance and updating represents a significant barrier, as highlighted by Musarat et al. (2023). Technical proficiency ensures that BIM models provide accurate and relevant information throughout a building's life cycle. Resistance to adopting new technologies and integrating them into the existing work culture is another substantial challenge despite the demonstrated benefits of BIM (Kassem et al., 2015). The next barrier is the lack of defined integration guidelines, which results in unclear workflows for BIM applications within organisations, complicating the coordination of multiple stakeholders and software applications (Becerik-Gerber et al., 2012). Additionally, limited access to learning materials and academic resources contributes to the knowledge gap among construction professionals, hindering BIM adoption (Musarat et al., 2023). High investment costs required for full BIM implementation in the O&M phase create financial barriers, making it difficult for stakeholders to allocate resources, especially since O&M phases typically have longer return-on-investment periods (Singh et al., 2011).

Legal barriers include challenges related to data ownership, copyright restrictions, and cybersecurity. Determining data ownership becomes complex in BIM-FM integration, as multiple systems operate simultaneously, complicating data assignment (Eadie et al., 2013; Irizarry et al., 2014). Legal requirements, such as insurance and licensing, often restrict data reuse, making it challenging to understand copyright limitations associated with different data types (Eadie et al., 2013; Irizarry et al., 2014). Ensuring data security is vital, as a cybersecurity breach could jeopardize the integrity and confidentiality of BIM information (Kassem et al., 2015). Consequently, many contractual documents continue to be managed as physical paper copies in the O&M phase, which are susceptible to loss and retrieval difficulties.

## 2.5 Strategies for Implementing Building Information Modelling for the Operation and Maintenance Phase of Building Life Cycle

In pursuing advancing Facility Management (FM) operations through Building Information Modelling (BIM), this section explores strategies to overcome the barriers associated with BIM implementation.

While BIM offers numerous advantages in streamlining building management throughout the entire lifecycle, implementation barriers necessitate identifying strategies to motivate and give confidence to the FM industry players. The first strategy is utilising BIM education to mitigate the technical issues associated with files and systems in the context of the FM industry. A solid understanding of BIM within the FM sector enables the seamless sharing of data and efficient information transfer among FM practitioners (Antwi-Afari et al., 2018; Lin et al., 2016). Another critical strategy involves ensuring sufficient funding for the comprehensive implementation of BIM during the operation and maintenance phase of a building's lifecycle. Cao et al. (2014) emphasise the importance of clients with expertise and commitment who can influence BIM implementation by providing financial resources. Consistent funding fosters a culture of innovation within the FM industry, instilling confidence among facilities management companies regarding adopting BIM technology and ensuring ongoing support for operations, maintenance, and enhancements (Cao et al., 2014).

Additionally, implementing a comprehensive training program tailored to FM practitioners is a crucial strategy for effective BIM integration in the operation and maintenance phase (Lin et al., 2016). Such training addresses potential hurdles associated with BIM utilisation in the O&M phase, equipping FM staff with the essential skills to overcome these challenges. Furthermore, establishing clear and well-defined objectives is a strategic imperative for successful BIM implementation in the operation and maintenance phase (Xu et al., 2020). These objectives provide FM stakeholders with a comprehensive understanding of the purpose and benefits of integrating BIM into this phase. By articulating the goals of BIM implementation, stakeholders are more likely to recognise the value it brings to their operations, fostering a sense of purpose and commitment (Xu et al., 2020; Lin et al., 2016). Motivation plays a central role in the strategy for successful BIM implementation within FM practices (Misron et al., 2018). The authors underscore motivation as a critical factor in adopting advanced technologies like BIM and emphasising collaborative efforts among facilities managers emerges as a strategy to drive technological advancement within the FM industry. Lastly, Amuda-Yusuf (2018) recognises collaboration among facilities managers as a strategic step towards implementing BIM. This collaborative approach recognises that successful integration of BIM goes beyond individual efforts. According to the author, by pooling facilities managers' expertise and experience, they can realise the full potential of BIM technology.

Durdyev et al. (2022) observed that the industry stakeholders need to commit additional resources to help overcome the barriers and enable a wider application of BIM for FM. Increased application of BIM for FM will have positive implications for the future of the FM industry and digital future of the built environment, which has been a national strategy.

## 3. Methodology

This study aims to explore strategies to enhance the implementation of Building Information Modelling (BIM) for the Operation and Maintenance (O&M) phase of the building life cycle in Malaysia. To achieve this aim, three specific objectives were established. The study objectives involve examining the current state of BIM implementation in this phase, identifying barriers hindering its implementation, and proposing strategies for implementing BIM for the O&M phase of the building life cycle in Malaysia. Data for this study were primarily gathered through a questionnaire survey, which was structured into four (4) sections: Section A, Section B, Section C, and Section D. Section A encompassed respondent and organisational background information, comprising Part 1 and Part 2. Section B was further divided into two parts, exploring the organisation's involvement in BIM implementation and its utilization for facilities management services. Section C focused on the barriers to implementing BIM in the O&M phase of the building life cycle, while Section D concentrated on strategies for its implementation.

This study adopts convenience sampling approach for data collection due to the population size for the study is relatively small. The study sample consisted of Grade G7 facilities management companies operating in the Klang Valley, registered under category F with the Construction Industry Development Board (CIDB), specializing in general building and infrastructure facilities (F01). The questionnaire was distributed using various communication channels, including email, telephone calls, LinkedIn, and physical distribution. Lastly, data analysis was conducted using the Statistical Package for Social Science (SPSS) software.

## 4. Results

This study focuses on the barriers encountered by facilities management companies when integrating BIM and the strategies they employ for its implementation. Thirty-two (32) samples from the questionnaire have been collected for these findings. Table 1 provides the overview of the respondent's background, while Table 2 presents details about the organisations' background.

**Table 1** *Respondents' background*

| Respondents' Background | Total Respondent | % |
|---|---|---|
| GENDER: | | |
| Male | 21 | 65.6 |
| Female | 11 | 34.4 |
| QUALIFICATION LEVEL: | | |
| Diploma | 2 | 6.3 |
| Bachelor's Degree | 25 | 78.1 |
| Master/PHD | 5 | 15.6 |
| YEARS OF EXPERIENCE: | | |
| 1 – 5 years | 7 | 21.9 |
| 6 – 10 years | 16 | 50.0 |
| 11 – 15 years | 5 | 15.6 |
| More than 15 years | 4 | 12.5 |
| INVOLVEMENT IN BIM | | |
| None | 31 | 96.9 |
| BIM Manager | 0 | 0.0 |
| BIM Modeler | 0 | 0.0 |
| BIM Coordinator | 1 | 3.1 |
| BIM Instructor | 0 | 0.0 |

**Table 2** *Organisations' background*

| Organisation's Background | Total Respondent | % |
|---|---|---|
| Years of Establishment: | | |
| Less Than 5 Years | 3 | 9.4 |
| 6 – 10 Years | 3 | 9.4 |
| 11 – 15 Years | 2 | 6.3 |
| More Than 15 Years | 24 | 75.0 |
| Number of Staff in the Organisation: | | |
| Less Than 50 | 3 | 9.4 |
| 51 – 100 | 4 | 12.5 |
| 101 – 150 | 7 | 21.9 |
| More Than 150 | 18 | 56.3 |
| Number Of Staff with BIM Experience: | | |
| None | 14 | 43.8 |
| 1 – 5 | 12 | 37.5 |
| 6 – 10 | 2 | 6.3 |
| More Than 10 | 4 | 12.5 |
| Supportive To Staff for BIM Related Training: | | |
| Yes | 13 | 40.6 |
| No | 19 | 59.4 |

The respondents are asked about the organisation's involvement in BIM implementation, such as experience in BIM projects and the number of BIM projects for facilities management undertaken by the respondent company. The respondents are also required to choose the usage of BIM in five Facilities Management Services. Table 3 and Table 4 below present the results of these questions answered by the respondents.

**Table 3** *Organisations' involvement in Building Information Modelling*

| Organisations' Involvement in BIM | Total Respondent | % |
|---|---|---|
| EXPERIENCE IN BIM PROJECT: | | |
| No experience | 27 | 84.4 |
| Less than 5 years | 5 | 15.6 |
| 6 – 10 years | 0 | 0.0 |
| 11 – 15 years | 0 | 0.0 |
| More than 15 years | 0 | 0.0 |
| NUMBER OF BIM PROJECT: | | |
| None | 27 | 84.4 |
| 1 - 5 | 5 | 15.6 |
| 6 - 10 | 0 | 0.0 |
| More than 10 | 0 | 0.0 |

The results show that most respondents (84.4%) have no experience with BIM projects, and many organisations (84.4%) have not undertaken BIM projects for facilities management. Furthermore, a smaller proportion of respondents and organisations do have some involvement in BIM projects, particularly in the range of 1 to 5 projects. The findings reveal that implementation of BIM in the O&M phase is still relatively low and supported by Dong et al. (2014), who mentioned the utilisation of BIM for facilities management still needs to be improved. Moreover, Ariffin et al. (2021) mentioned that awareness of BIM-FM integration in Malaysian facilities is still low, resulting in minimal implementation of BIM during the O&M phase of buildings in Malaysia.

**Table 4** *Building Information Modelling (BIM) implementation in facilities management services*

| Building Information Modelling (BIM) Implementation in Facilities Management Services | | | Not Sure | | Yes | | No | |
|---|---|---|---|---|---|---|---|---|
| | | | Qty | % | Qty | % | Qty | % |
| 1. | Daily operation of the building | By monitoring the equipment's operational parameters in real time, the Building Information Modelling (BIM) model can determine whether or not the equipment is functioning properly. | 15 | 46.9 | 17 | 53.1 | 0 | 0.0 |
| 2 | Maintenance and repair | Information about building systems recorded in Building Information Modelling (BIM) models can be utilised to create a database for preventative maintenance. | 13 | 40.6 | 19 | 59.4 | 0 | 0.0 |
| 3 | Energy management | Building Information Modelling (BIM) can facilitate the analysis and comparison of various energy options, allowing facility managers to reduce environmental impacts and operating expenses. | 20 | 62.5 | 12 | 37.5 | 0 | 0.0 |
| 4 | Space management | By integrating building data into Building Information Modelling (BIM), organisations are able to manage space, such as leased space, control rental income, reduce vacancy, and ultimately reduce real estate costs significantly. | 19 | 59.4 | 13 | 40.6 | 0 | 0.0 |
| 5 | Hazardous waste management and recycling | Building Information Modelling (BIM) can assist in measuring energy consumption and waste. | 22 | 68.8 | 8 | 25.0 | 2 | 6.3 |

In terms of using BIM for facilities management services, Table 4 shows that the majority of the respondents (53.1%) are in favour of implementing BIM for daily building operations, which is in line with the potential benefits of BIM for streamlining and improving daily operational activities. Next, 59.4% of the respondents selected maintenance and repair as one of the facilities management services that can be utilised using BIM. The endorsement of the implementation of BIM for maintenance and repair indicates recognition of its potential to improve these important aspects of facility management. These two services align with Hoang et al. (2020), who mentioned that BIM can be used for the daily operation of the building and the maintenance and repair of the building.

A total of 12 barriers are identified and listed for the respondents to choose. The questionnaire format is designed using the Likert scale method on a scale of 1-6, with 1 being the 'Not Sure' and 6 being the 'Strongly Agree'. The results of these questions are shown in Table 5.

A total of seven (7) strategies are identified and listed for the respondents to choose. The format of the questionnaire is designed using the Likert scale method, on a scale of 1-6, with 1 being the 'Not Sure' and 6 being the 'Strongly Agree'. The results of these questions are shown in Table 6.

**Table 5** *Barriers to the implementation of Building Information Modelling (BIM) for operation and maintenance phase of building*

| No. | Barriers to the Implementation of Building Information Modelling (BIM) for Operation and Maintenance Phase of Building Life Cycle | Not Sure | | Strongly Disagree | | Disagree | | Neutral | | Agree | | Strongly Agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Qty | % | Qty | % | Qty | % | Qty | % | Qty | % | Qty | % |
| | Technical Barriers | | | | | | | | | | | | |
| 1. | Existing technologies are unable to satisfy the interoperability requirements of Building Information Modelling (BIM) technology | 9 | 28.1 | 1 | 3.1 | 3 | 9.4 | 11 | 34.4 | 8 | 25.0 | 0 | 0.0 |
| 2. | High complexity of the facility information in Building Information Modelling (BIM) software | 4 | 12.5 | 0 | 0.0 | 1 | 3.1 | 7 | 21.9 | 20 | 62.5 | 0 | 0.0 |
| | Organisational Barriers | | | | | | | | | | | | |
| 3. | Lack of technical expertise among practitioners of facilities management | 4 | 12.5 | 0 | 0.0 | 1 | 3.1 | 2 | 6.3 | 18 | 56.3 | 7 | 21.9 |
| 4. | Rigid industry culture refuses to accept the implementation of new technology | 4 | 12.5 | 4 | 12.5 | 8 | 25.0 | 7 | 21.9 | 8 | 25.0 | 1 | 3.1 |
| 5. | Unclear workflow for Building Information Modelling (BIM) application within an organisation | 3 | 9.4 | 1 | 3.1 | 2 | 6.3 | 8 | 25.0 | 17 | 53.1 | 1 | 3.1 |
| 6. | Lack of learning materials prepared by the academic institutions | 3 | 9.4 | 0 | 0.0 | 2 | 6.3 | 7 | 21.9 | 15 | 46.9 | 5 | 15.6 |
| 7. | Lack of learning equipment prepared by the academic institutions | 3 | 9.4 | 0 | 0.0 | 2 | 6.3 | 7 | 21.9 | 15 | 46.9 | 5 | 15.6 |
| 8. | Insufficient research to investigate the Building Information Modelling (BIM) technology adoption | 3 | 9.4 | 0 | 0.0 | 4 | 12.5 | 13 | 40.6 | 10 | 31.3 | 2 | 6.3 |
| 9. | High cost of investment for Building Information Modelling (BIM) software for the O&M phase of building life cycle. | 3 | 9.4 | 0 | 0.0 | 1 | 3.1 | 1 | 3.1 | 13 | 40.6 | 14 | 43.8 |
| | Legal Barriers | | | | | | | | | | | | |
| 10. | Unclear determination of copyright regarding Building Information Modelling (BIM) data. | 7 | 21.9 | 0 | 0.0 | 0 | 0.0 | 16 | 50.0 | 7 | 21.9 | 2 | 6.3 |
| 11. | Hard to distinguish the ownership of Building Information Modelling (BIM) data. | 10 | 31.3 | 1 | 3.1 | 3 | 9.4 | 9 | 28.1 | 7 | 21.9 | 2 | 6.3 |
| 12. | Lack of cyber security maturity for the project data to be stored digitally. | 9 | 28.1 | 0 | 0.0 | 5 | 15.6 | 14 | 43.8 | 3 | 9.4 | 1 | 3.1 |

**Table 6** *Strategies for implementing Building Information Modelling (BIM) for the operation and maintenance phase of building life cycle*

| No. | Strategies for Implementing Building Information Modelling (BIM) for the Operation and Maintenance Phase of Building Life Cycle | Not Sure | | Strongly Disagree | | Disagree | | Neutral | | Agree | | Strongly Agree | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Qty | % | Qty | % | Qty | % | Qty | % | Qty | % | Qty | % |
| 1. | Building Information Modelling (BIM) education to reduce technical issues related to files | 4 | 12.5 | 0 | 0.0 | 0 | 0.0 | 3 | 9.4 | 20 | 62.5 | 5 | 15.6 |
| 2. | Building Information Modelling (BIM) education to reduce technical issues related to systems | 4 | 12.5 | 0 | 0.0 | 0 | 0.0 | 3 | 9.4 | 19 | 59.4 | 6 | 18.8 |
| 3. | Adequate funding to fully implement Building Information Modelling (BIM) software into the O&M phase of building life cycle | 3 | 9.4 | 0 | 0.0 | 0 | 0.0 | 4 | 12.5 | 17 | 53.1 | 8 | 25.0 |
| 4. | Provide training for facilities management practitioners | 3 | 9.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 19 | 59.4 | 10 | 31.3 |
| 5. | Clear definition of objectives for the implementation of Building Information Modelling (BIM) | 6 | 18.8 | 0 | 0.0 | 1 | 3.1 | 6 | 18.8 | 13 | 40.6 | 6 | 18.8 |
| 6. | Motivate to use Building Information Modelling (BIM) in the Facilities Management practices | 5 | 15.6 | 0 | 0.0 | 1 | 3.1 | 12 | 37.5 | 11 | 34.4 | 3 | 9.4 |
| 7. | Excellent collaboration among facilities managers in adopting modern technologies | 5 | 15.6 | 0 | 0.0 | 0 | 0.0 | 5 | 18.8 | 17 | 53.1 | 4 | 12.5 |

## 5. Discussions

As shown in Table 7, the significant barriers, the top six (6) barriers in the respondents' rate, which obtained more than 50% agreement were listed for discussion. Among the respondents, 84.4% identified the high investment cost in BIM software as the most significant barrier to implementing BIM during the O&M phase of the building life cycle. It is crucial to have sufficient resources for facility stakeholders to acquire all the essentials and completely implement BIM software in the operation and maintenance phase. Singh et al. (2011) emphasised the initial investment required for BIM adoption. Next, the significant barrier is the lack of technical expertise among practitioners in facilities management. This barrier correlates with the findings by Musarat et al. (2023). The authors mentioned that technical proficiency is essential to ensure accurate and relevant information is available for decision-making. Without adequate technical expertise, FM practitioners may struggle to harness the full potential of BIM.

Furthermore, the respondents agree that the high complexity of facility information within BIM software is a significant barrier. The result is consistent with the findings by Irizarry et al. (2014), who found that the high complexity may result in inaccuracies due to data inaccessibility. The authors pointed out the concern of merging the facility information in BIM software due to its high complexity due to the design and construction phases being synonymous with creating a large number of files in various formats. The following barriers, with equal representation at 62.5%, are the lack of learning materials and equipment provided by academic institutions to facilitate the implementation of Building Information Modelling (BIM) applications. BIM education should be implemented in all the higher education institutions in Malaysia to prepare young talents for adapting to the transformation of industry. The findings align with recent research conducted by Musarat et al. (2023), who agreed on the lack of BIM-related knowledge, skills, and training within the Malaysian context.

The last barrier from the top six barriers that obtained more than 50% agreement is the lack of clarity surrounding the workflow associated with BIM applications within organisations during the O&M phase (56.2% respondents). This unclear workflow encompasses various dimensions, including task allocation, role definition, role functionalities, data sharing timelines through BIM, and the mechanics of utilising BIM. This outcome closely aligns with the findings of Becerik-Gerber et al. (2012), who claimed that the complex processes inherent to BIM and the multiple tasks associated with facilities management contribute to the unclear workflows related to BIM applications within an organisation.

**Table 7** *Summary of the barriers to the implementation of Building Information Modelling (BIM) for operation and maintenance phase of building*

| No. | Barriers to the Implementation of Building Information Modelling (BIM) for Operation and Maintenance Phase of Building Life Cycle | Agree + Strongly Agree | |
|---|---|---|---|
| | | Qty | % |
| 1. | High cost of investment for Building Information Modelling (BIM) software for the O&M phase of building life cycle. | 27 | 84.4 |
| 2. | Lack of technical expertise among practitioners of facilities management | 25 | 78.2 |
| 3. | High complexity of the facility information in Building Information Modelling (BIM) software | 20 | 62.5 |
| 4. | Lack of learning materials prepared by the academic institutions | 20 | 62.5 |
| 5. | Lack of learning equipment prepared by the academic institutions | 20 | 62.5 |
| 6. | Unclear workflow for Building Information Modelling (BIM) application within an organisation | 18 | 56.2 |

As shown in Table 8, the top six strategies in the respondents' rate, which obtained more than 50% agreement, were listed for discussion. The most significant strategy for successfully implementing Building Information Modelling (BIM) in the operation and maintenance (O&M) phase of the building life cycle is providing comprehensive training for facilities management practitioners. This strategy obtained agreement from 90.7% of respondents. Comprehensive training is crucial to equip stakeholders with the necessary skills to use BIM software effectively. Training for FM staff is essential to ensure they are proficient in using BIM, managing the data and ensuring data interoperability. This finding is consistent with those of other researchers, such as Lin et al. (2016) and Eastman et al. (2011), who emphasise the importance of BIM training for facilities management practitioners as a strategy to implement BIM for the O&M phase of the building life cycle. The next strategy that obtained more than 50% agreement is BIM education to mitigate technical issues related to files and systems. Both strategies, BIM education to mitigate issues related to (1) files and (2) systems, received agreement from 78.1% of respondents. These strategies align with the findings by Antwi-Afari et al. (2018) and Lin et al. (2016). The authors highlight the importance of knowledge in the context of BIM adoption and emphasise that a solid understanding of BIM within the FM sector enables the seamless sharing of data and efficient transfer of important information among FM practitioners. Hence, Building Information Modelling (BIM) education can be an effective strategy to mitigate the technical issues associated with files and systems in the context of the FM industry.

Adequate funding to fully integrate the BIM software into the O&M phase as a strategy receives agreement from 78.1% of respondents. Adequate funding is closely related to software procurement, hardware acquisition and staff training. This result is consistent with Cao et al. (2014), who stress that adequate funding will contribute to faster adoption by providing sufficient financial resources for BIM software packages, licences, and regular upgrades. Therefore, providing the necessary financial resources can significantly influence the implementation of BIM. Next, excellent collaboration among facilities managers in implementing BIM receives agreement from 65.6% of respondents. This strategy aligns with the findings by Amuda-Yusuf (2018) that the BIM competencies of FM stakeholders can be improved through joint efforts, which ultimately drives the successful implementation of BIM. The last strategy from the top six that obtained more than 50% agreement is the clear definition of objectives for BIM implementation (59.4%). When implementing BIM, establishing a clear and well-defined objective is crucial in communicating the purpose and benefits of using BIM in the O&M phase. This strategy is consistent with the findings of Xu et al. (2020) and Lin et al. (2016), which emphasise the strategic importance of understanding objectives and executing plans in the pre-operational phase for successful BIM implementation for the O&M phase of the building life cycle.

**Table 8** *Summary of the strategies for implementing Building Information Modelling (BIM) for the operation and maintenance phase of building life cycle*

| No. | Strategies for Implementing Building Information Modelling (BIM) for the Operation and Maintenance Phase of Building Life Cycle | Agree + Strongly Agree | |
|---|---|---|---|
| | | Qty | % |
| 1. | Provide training for facilities management practitioners | 29 | 90.7 |
| 2. | Building Information Modelling (BIM) education to reduce technical issues related to files | 25 | 78.1 |
| 3. | Building Information Modelling (BIM) education to reduce technical issues related to systems | 25 | 78.1 |
| 4. | Adequate funding to fully implement Building Information Modelling (BIM) software into the O&M phase of building life cycle | 25 | 78.1 |
| 5. | Excellent collaboration among facilities managers in adopting modern technologies | 21 | 65.6 |
| 6. | Clear definition of objectives for the implementation of Building Information Modelling (BIM) | 19 | 59.4 |

## 6. Conclusion

The study concludes that implementing Building Information Modelling (BIM) for the O&M phase of the building life cycle in Malaysia is low. Many respondents and organisations have limited or no experience with BIM projects. However, respondents recognise the potential benefits of BIM for daily building operations and maintenance and repair and are unsure of the benefits of BIM for energy management, space management and hazardous waste management. The findings from the questionnaire survey highlight the top six (6) significant barriers to implementing BIM for the operation and maintenance phase of the building life cycle, which are high-cost investment, lack of technical expertise, complex facility information, lack of preparation of materials and equipment by academic institutions, and unclear workflows within organisations. In addition, the study finds that possible strategies that can be proposed are comprehensive training, BIM education to reduce technical issues related to files and systems, secured funding, collaboration among FM stakeholders, and clearly defined objectives. Finally, the study suggests that future research could widen the scope of respondents beyond Facilities Management Contractors in the Klang Valley and Grade G7. Widening the scope includes respondents from different grades, regions and stakeholders representing different phases of the facility lifecycle.

## 7. Limitations

The following limitations are acknowledged and should be read together with the findings of the study:
1. Sample size of 32 responses is small for robust quantitative analysis.
2. Lack of BIM experiences of among respondents of the study although they are attached to organisations involving operation and maintenance phase of building life cycle.

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## Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *Keng, T.C., Fadhaililamal, F.H. Author 2;* ***data collection:*** *Fadhaililamal, F.H;* ***analysis and interpretation of results:*** *Fadhaililamal, F.H.;* ***draft manuscript preparation:*** *Keng, T.C., Fadhaililamal, F.H. All authors reviewed the results and approved the final version of the manuscript.*

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