APPLICATION OF BUILDING INFORMATION MODELING IN CAMPUS FACILITIES MANAGEMENT: A CASE STUDY OF UNIVERSITI UTARA MALAYSIA

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UNIVERSITI UTARA MALAYSIA

AUGUST 2025

APPLICATION OF BUILDING INFORMATION MODELING IN CAMPUS FACILITIES MANAGEMENT: A CASE STUDY OF UNIVERSITI UTARA MALAYSIA

BY

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Thesis Submitted to

College of Business

Universiti Utara Malaysia,

in Partial Fulfillment of the Requirement for the Master of Sciences (project Management)

Kolej Perniagaan
(College of Business)
Universiti Utara Malaysia

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Program Pengajian *(Programme of Study)*	:	**Master of Science (Project Management)**
Nama Penyelia/Penyelia-penyelia *(Name of Supervisor/Supervisors)*	:	**Prof. Sr. Dr. Mohd Nasrun Mohd Nawi** Tandatangan
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ABSTRACT

This study aims to explore the feasibility of applying Building Information Modeling (BIM) in the campus facilities management of Universiti Utara Malaysia (UUM), serving as a representative case of facilities management scenarios in Malaysian higher education. With the expansion and aging of building assets in universities, the traditional management model has gradually exposed problems such as fragmented information, delayed response, and weak cross-departmental collaboration. As a digital integration platform covering the entire building lifecycle, BIM has demonstrated significant advantages in global construction management. However, its application in Malaysian higher education facilities management remains in its infancy. This study adopted a qualitative case study method, using semi-structured interviews with staff from UUM's Development and Maintenance Department (JPP) as the primary data source, and conducted open, axial, and selective coding analyses using NVivo. The research identified key issues and their underlying causes in the current management system, and through thematic analysis, distilled five feasibility dimensions for BIM implementation: system adaptability, management improvement drive, organizational willingness to accept, capacity and resource guarantee, and strategic promotion mechanism. The findings indicate that BIM is conditionally feasible in UUM, with successful implementation depending on organizational commitment, technical readiness, and supportive policies.

This research fills a gap in the application of BIM in campus facilities management in Malaysian universities and provides a structured practical pathway and theoretical reference for the digital transformation of higher education institutions.

Keywords: Building Information Modeling (BIM); Campus Facilities Management; Feasibility; UUM; NVivo; Qualitative Research

ABSTRACT

Kajian ini bertujuan untuk meneroka kebolehlaksanaan penggunaan Building Information Modeling (BIM) dalam pengurusan fasiliti kampus di Universiti Utara Malaysia (UUM), yang berfungsi sebagai kajian kes representatif bagi senario pengurusan fasiliti dalam pendidikan tinggi di Malaysia. Dengan perkembangan serta penuaan aset bangunan di universiti, model pengurusan tradisional semakin menonjolkan masalah seperti maklumat yang berpecah-pecah, tindak balas yang tertangguh, dan kerjasama rentas jabatan yang lemah. Sebagai sebuah platform integrasi digital yang merangkumi keseluruhan kitar hayat bangunan, BIM telah menunjukkan kelebihan yang ketara dalam pengurusan pembinaan di peringkat global. Walau bagaimanapun, penggunaannya dalam pengurusan fasiliti pendidikan tinggi di Malaysia masih berada pada peringkat awal.

Kajian ini menggunakan kaedah kajian kes kualitatif, dengan temu bual separa berstruktur bersama staf daripada Jabatan Pembangunan dan Penyelenggaraan (JPP) UUM sebagai sumber data utama, serta menjalankan analisis pengekodan terbuka, paksi, dan selektif menggunakan perisian NVivo. Penyelidikan ini mengenal pasti isu-isu utama dan punca asas dalam sistem pengurusan semasa, dan melalui analisis tema, merumuskan lima dimensi kebolehlaksanaan pelaksanaan BIM: kebolehsuaian sistem, pemacu penambahbaikan pengurusan, kesediaan organisasi untuk menerima, jaminan kapasiti dan sumber, serta mekanisme promosi strategik.

Hasil kajian menunjukkan bahawa BIM mempunyai kebolehlaksanaan bersyarat di UUM, dengan kejayaan pelaksanaannya bergantung kepada komitmen organisasi, kesiapsiagaan teknikal, dan sokongan dasar. Kajian ini mengisi jurang dalam literatur mengenai aplikasi BIM dalam pengurusan fasiliti kampus di universiti-universiti Malaysia dan menyediakan laluan praktikal yang tersusun serta rujukan teori untuk transformasi digital institusi pendidikan tinggi.

Kata kunci: Building Information Modeling (BIM); Pengurusan Fasiliti Kampus; Kebolehlaksanaan; UUM; NVivo; Penyelidikan Kualitatif

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to all who supported me throughout this research journey.

Special thanks go to my supervisor, Prof. Sr. Dr. Mohd Nasrun Bin Mohd Nawi, for his continuous guidance, constructive feedback, and encouragement, which were instrumental in shaping this study.

I am also grateful to the JPP of Universiti Utara Malaysia for their cooperation, and to the staff members who participated in the interviews and shared valuable insights.

My heartfelt thanks go to my family and friends for their unwavering support and understanding.

Lastly, I thank Universiti Utara Malaysia for providing the academic environment and resources that enabled the completion of this research.

Thank you all.

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LIST OF ABBREVIATIONS

UUM: Universiti Utara Malaysia

BIM: Building Information Modeling

FMS: Facilities Management System

JPP: Development and Maintenance Department

AECO: Architecture, Engineering, Construction and Operation

CIDB: Construction Industry Development Board Malaysia

CHAPTER 1: INTRODUCTION

1.1 Introduction

With the expansion of the scale of global higher education and the acceleration of the digitalization trend, universities in various countries are facing increasingly complex challenges in the facilities management of campus buildings (Nizar & M'hamed, 2023). The demand for campus infrastructure shows a high degree of uncertainty and diversity. The usage load of teaching, research and living facilities has increased due to changes in student mobility structure, internationalization degree and research direction (Kulaga, 2015; Sankari et al., 2018).

Furthermore, the instability of funding sources has prompted universities to explore multiple financing mechanisms to maintain facilities renewal (McCann et al., 2019), which has led to tight and temporary characteristics in resource allocation. Many university campuses still have problems such as aging facilities, scattered buildings, and low space utilization efficiency, which seriously affect management efficiency and user experience (Den Heijer & Tzovlas, 2014).

Due to the diversity, high density and functional complexity of university buildings, their management requirements are far higher than those of general building types. The space scheduling and maintenance work in places such as teaching buildings, dormitories, libraries, office areas, and experimental centers require efficient collaboration and precise decision-making. However, especially in developing countries such as Malaysia, most universities still mainly rely on traditional manual bookkeeping and departmental decentralized management, and there are widespread problems such as data fragmentation, low communication efficiency, and slow response (Nafrizon et al., 2020).

Against this backdrop, BIM is regarded as a key tool to break through management bottlenecks. BIM has the capabilities of information integration, visualization and cross-departmental collaboration, which can significantly improve the efficiency of facilities management, extend the building life cycle and optimize the operation strategy (Azhar et al., 2012). Although BIM has been widely applied in commercial buildings and government projects, its adoption in the facilities management of universities in Malaysia remains in its infancy, and relevant research and practical exploration are still lacking. Therefore, evaluating its feasibility in university building facilities management, especially taking the developing higher education system represented by Malaysia as the object, has significant theoretical value and practical significance.

1.2 Problem Statement

Building upon this context, the limited adoption of BIM in Malaysian universities reflects a broader global research gap. Although BIM has been widely implemented in the global construction industry, particularly demonstrating significant advantages in design integration, construction management, and asset delivery, its application in the facilities management stage of campus buildings within higher education institutions remains underexplored. Existing literature predominantly focuses on commercial and government buildings, offering limited insights into the unique operational environment of universities, which is characterized by multi-departmental collaboration, high usage frequency, and diverse functional requirements. Consequently, there is a lack of systematic research to address the specific challenges and opportunities of BIM adoption in this context.

In Malaysia, many universities still rely on traditional manual or decentralized systems for building and facilities management. These practices often lead to problems such as lagging maintenance response, scattered and isolated information, and inefficient utilization of space resources, making it difficult to adapt to the trend of digital and intelligent management (Ghaffarianhoseini et al., 2017). This reveals the serious bottlenecks in the current management of university buildings in terms of technology integration, organizational coordination and cost control.

However, there is still limited empirical research on the feasibility of BIM in campus facilities management in Malaysian universities, especially lacking in-depth discussions that combine actual cases, data analysis and feedback from managers. This not only restricts the academic community's assessment of the value of BIM but also limits the choice of digital transformation paths for universities in the field of building management. This gap limits the ability of universities to utilize digital tools for strategic facilities planning, resource optimization, and achieving long-term sustainability. Against this backdrop, conducting a feasibility study on the application of BIM is of vital importance for guiding future digital infrastructure investment and policy making in Malaysia's higher education sector.

Therefore, this study focuses on UUM as a case, examining the potential advantages, implementation obstacles, and supporting conditions for BIM in addressing typical campus facilities management challenges. Using semi-structured interviews and NVivo coding analysis, the study aims to assess the feasibility of BIM and provide both theoretical insights and practical guidance for policymakers, facilities managers, and relevant government agencies.

1.3 Research Question

This study aims to answer the following questions:

i. What are the main problems existing in the campus facilities management of UUM?

ii. What are the main causes of these problems?

iii. What obstacles might UUM encounter during the implementation of BIM, such as insufficient technical capabilities, organizational inertia or lack of strategic support?

iv. How can BIM provide potential solutions for addressing campus facilities management issues?

v. What key supporting conditions are needed for the successful implementation of BIM in campus facilities management?

1.4 Research Objective

The main objectives of this study include:

i. To identify and analyze the key problems in campus facilities management at UUM.
ii. To investigate the underlying causes contributing to these problems.
iii. To examine potential obstacles to BIM implementation at UUM.
iv. To explore the potential of BIM as a feasible solution to address identified management issues.
v. To determine the key enabling conditions for the successful adoption of BIM in campus facilities management.

1.5 Research Significance

This study is significant in both academic and practical dimensions. From an academic perspective, it addresses the underexplored area of BIM application in campus facilities management in the Malaysian higher education context, thereby contributing to discourse on digital transformation in public sector infrastructure management. From a practical standpoint, the findings can guide university decision-makers in evaluating the relevance of BIM to operational needs and formulating more effective strategies for technology adoption and resource optimization.

1.6 Research Scope

To ensure focus and research feasibility, this study specifically examines the feasibility of applying BIM in the campus facility management stage of UUM. It investigates the existing problems in campus facilities management from the perspectives of communication, resource allocation, and building aging. The study does not address BIM applications in the design or construction phase, nor does it evaluate BIM software tools in technical depth. Instead, it emphasizes managerial, organizational, and policy aspects of BIM feasibility in the facilities management context of Malaysian public universities.

1.7 Definition of Key Terms

Building Information Modeling (BIM): Intelligent building management platform.

Campus Facilities Management: The management of campus buildings and assets to ensure efficiency, maintenance, optimal space use, and user comfort across all functions.

Facilities Management System (FMS): A system for reporting facility issues, tracking maintenance, and generating reports.

NVivo: A software tool used for qualitative data coding and analysis.

1.8 Organization of the Study

Chapter 1: Presents the research background, problem statement, research objectives, scope, and clarifies the overall research logic.

Chapter 2: Reviews relevant theories and practices related to BIM and campus facility management and identifies the research gaps.

Chapter 3: Describes the research design, data collection procedures, and analysis methods.

Chapter 4: Analyzes the research questions based on NVivo coding results and summarizes the five feasibility dimensions.

Chapter 5: Summarizes the key findings and contributions, provides practical recommendations, and outlines limitations and directions for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter aims to systematically sort out the theoretical development and practical application of BIM in the field of building management, laying a theoretical foundation for exploring its feasibility in the campus facilities management of UUM. Firstly, by clarifying the core definition, technical characteristics and global development trends of BIM, its multi-dimensional value as a digital management tool is clarified; secondly, focusing on the common pain points of facilities management, the limitations of the traditional campus management model are analyzed; then, combined with 11 typical cases around the world, the practical benefits and challenges of BIM in facilities operation and maintenance, energy management and space optimization are empirically analyzed; finally, the local policy environment and technological ecology of Malaysia are examined, and the gap in existing research is pointed out: the lack of empirical evidence on the feasibility assessment of BIM in the facilities management stage of universities in developing countries, providing a theoretical entry point and innovation space for this study. The whole chapter integrates the literature from a critical perspective, constructs a three-dimensional analysis framework of "technology-management-context", and supports the design and implementation of subsequent empirical research.

2.2 Definition and Evolution of BIM

2.2.1 The Definition of BIM

BIM was first proposed by Professor Charles Eastman of Georgia Institute of Technology in his paper as the "Building Description System", which is the predecessor of BIM (Eastman, 1975). After decades of development, the development process of BIM definition is shown in Figure 2.1:

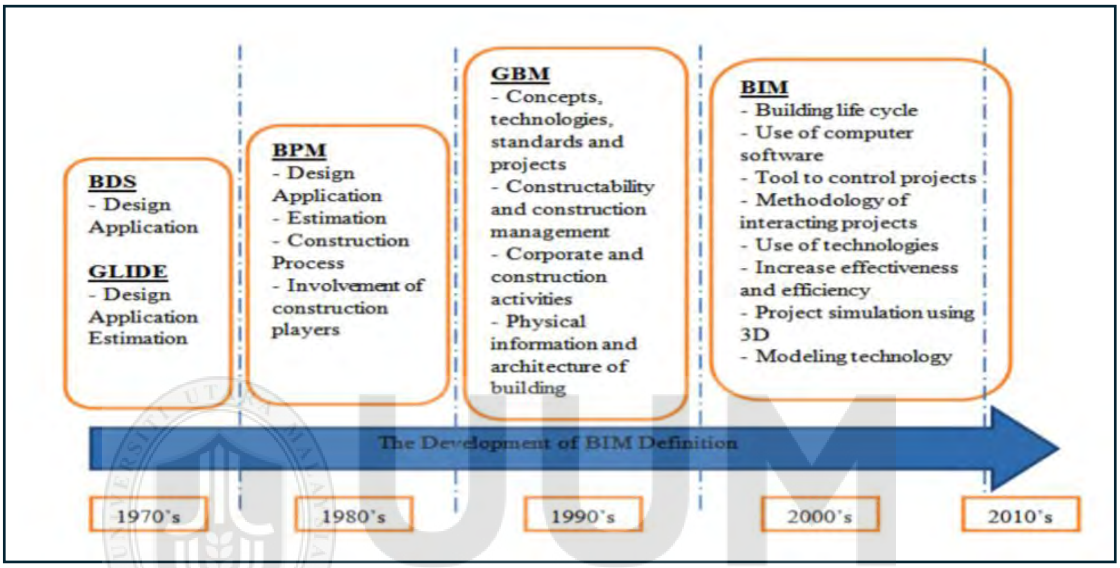

Figure 2.1 The Development of BIM Definition

Source: (Latiff et al., 2014).

Due to different implementation perspectives, such as designers, architects, construction workers, surveyors, customers or other stakeholders, the definitions of BIM in various standards and literatures have different emphases. The National BIM Standards Project Committee of the United States (NBIMS-US) believes that the essence and function of BIM is to emphasize its core value as a "digital information carrier" and "decision support basis". BIM is defined as a digital representation of objects, physical and functional characteristics. Therefore, it can serve as a universal knowledge resource for object information, providing a reliable basis for decision-making throughout the life cycle of the object from beginning to end (National Institute of Building Sciences, 2015). The British Standards Institute emphasizes the importance of BIM processes. BIM is not a technology, but a process. It is defined as: "BIM is the process of designing, constructing and operating buildings or infrastructure using object-oriented electronic information". In the relevant literature, Professor Eastman believes that BIM is a system or a group of systems that enable users to integrate and reuse building information and domain knowledge throughout the life cycle of a building (Lee et al., 2006). Later defined BIM as a modeling technology involving processes that support the creation, sharing, and analysis of building models (C. Eastman et al., 2008). Some researchers also believe that BIM is a set of technologies, policies and processes designed to manage important project data in the building life cycle in a digital format (Succar, 2009). BIM is becoming a new approach that includes the use of technology to improve collaboration and communication among construction participants and document management (Latiff et al., 2014).

In summary, the definition of BIM can be considered from two perspectives, a broader and a narrower one. BIM in a strict sense is a semantic database that accompanies the entire life cycle of a building object. BIM in a broad sense should be seen as part of a larger whole. As BIM develops, some definitions no longer meet the relevant attributes of BIM. Stakeholders can refer to the six key attributes of BIM divided into two groups: Technical (3D digital model, A repository of information and knowledge, Semantic database) and Organizational (Entire life cycle, Design, Construction and operation process, Management methodology) to define it. We no longer need to distinguish whether BIM is a technology, a process or a method. We can simply say that it is the result of people working together and bringing benefits (Borkowski, 2023). And the core feature of BIM is to achieve information interoperability, transmission and integration by developing and maintaining the data of the three-dimensional visualization model of the construction project, thereby improving the efficiency and quality of the construction project. BIM can integrate geometric data, time data, cost data and performance data of the construction project into a multidisciplinary collaborative environment and decision support platform (Azhar, 2011). This also lays the foundation for the multidimensionality of BIM.

2.2.2 The Development Trend of BIM

The concept of BIM has been further developed and applied to actual construction projects since the mid-2000s (Latiff et al., 2014). Especially in the late 2000s, with the improvement of computer technology and software tools, the application field of BIM has been widely developed (Succar, 2009). From the early 3D modeling to today's multi-dimensional: 4D construction schedule simulation, 5D budget control, 6D energy analysis, 7D operation and maintenance management, and 8D risk management (Sacks et al., 2018) .The multi-dimensionality of BIM is based on determining the required 3D modeling level, which is also called the level of development (LOD), including model accuracy requirements from LOD100-500 (Saptari et al., 2020). And it is widely used in the entire life cycle of construction projects, from pre-implementation, construction, operation and maintenance, and demolition stages (Borrmann et al., 2018). Based on the above functions, BIM also supports the use of multiple tools and software. For example, integrating IoT, AI, smart operation and maintenance (such as digital twins), Autodesk Revit, Bentley Systems, Tekla, etc. for joint design, construction or operation and maintenance; and dynamically associating the use of models and data (such as Revit and ArchiCAD software) for parametric modeling; using Industry Foundation Classes standards to ensure cross-platform data interoperability; cloud computing and collaborative platforms (such as BIM 360, Navisworks) support multi-party collaboration and conflict detection.

BIM has also been widely used in many countries and industries due to its multidimensional characteristics. In some countries and related industries, the implementation of BIM has made great progress, especially in developed countries. As one of the pioneering countries in BIM application, the United States has formulated BIM projects, goals and implementation roadmaps in its public institutions and issued relevant standards (Cheng & Lu, 2015). Since 2016, the British government has mandated the use of BIM in public projects to minimize waste, reduce costs and mitigate climate change (Bernstein et al., 2014). Singapore has established a BIM committee and issued several BIM guidelines. In developing countries, China also included BIM in the "12th Five-Year Plan" national plan in 2012 (Cheng & Lu, 2015). According (Ganah & Lea, 2021), 13 countries were surveyed in the study, and each country had an average of 13.2 BIM standards and guidelines in the AECO industry. Moreover, the standards issued by developed countries (such as Europe and the United States) are 5.2 times that of Asian countries (such as China). The pace of BIM standardization and globalization in the future is unstoppable (Ganah & Lea, 2021). However, compared with developed countries, developing countries have a low penetration rate of BIM use, no unified guidelines and industry standards, insufficient policy support, and are mostly concentrated in large-scale commercial projects. Stakeholders' awareness and cognition of BIM are also weak. According to future development trends, developing countries must increase policy support and guidance for BIM and let the market drive its development.

2.3 Facilities Management Challenges

2.3.1 Challenges in Public Building Facilities Management

Buildings are usually characterized by complexity and diversity, such as complex structural configurations, diverse functions, large flow of people or vehicles, and high safety requirements for facilities and equipment. With the increase in the number or complexity of new construction projects, daily management efficiency and operational safety issues are more important than ever. Both static and dynamic factors bring difficulties. For example, hospitals, like large public buildings, usually have hundreds of rooms, each with different usage requirements and partitions, and many mechanical and electrical systems are embedded. In daily activities, patients, family members, doctors and administrative staff may cause intensive and complex intersections and safety accidents. Therefore, the daily maintenance and repair system, precise management, management efficiency and operational safety of buildings are inevitable problems (Peng et al., 2020).

There is also a lack of relevant maintenance culture among stakeholders in the maintenance process, and the degree of abandonment and deterioration of public buildings is high and even aging and abandonment. Maintenance culture is essential for the maintenance of public buildings, which is of great significance to national development. It is also to prevent damage and injury to buildings and improve the practicality of the economic life of the structure while improving its functionality and aesthetics (Ogunbayo et al., 2022). For example, the maintenance of government buildings in Iraq is always affected by technical defects and administrative problems (Breesam & Jawad, 2021). In the process of building management, there are often problems with the lack of original information and the outsourcing of management work to third parties. For example, the famous Algeciras Market Hall in Spain was built a long time ago. Due to the incomplete original building information drawings and the maintenance and operation work being contracted by a third party, the structure has been used without any obvious maintenance work, and there are obvious problems with the exterior wall corrosion (Bazán et al., 2021). Building management also faces the risk of reduced building operation and maintenance budgets. This means that there are not enough resources to manage the building, affecting the normal and safe operation of the building (Pinti et al., 2022). Energy consumption is also an issue that cannot be ignored in building management: for example, public buildings, as one of the three major areas of building energy consumption, are facing the pressure of energy conservation, emission reduction and sustainable development, and their energy consumption accounts for 38% of the total energy consumption. The energy consumption level of public buildings is much higher than that of other civil buildings (Y. Liu et al., 2020).

2.3.2 Challenges in Campus Facilities Management

As important public spaces and building clusters, campus buildings share many characteristics with general facilities management, but these traits are often more pronounced in the campus context. Firstly, campus buildings are diverse in type, typically including administrative offices, libraries, staff dormitories, guest houses, laboratories, workshops, and other auxiliary facilities. The management scope is broad, covering both new and old buildings, with older facilities forming the majority and serving as primary activity spaces. The stakeholder network is also complex, involving university institutions, surrounding communities, students, faculty, and staff. More than 90% of students and a significant portion of faculty reside on campus. Secondly, campus facilities management operates under limited funds and resources. While government funding for educational institutions has generally increased (except for private campuses), many academic organizations still view building maintenance as a burden rather than a value-adding strategy. Corrective maintenance often receives priority only after problems occur, primarily due to budget constraints and shortages of qualified labor (Lateef et al., 2010). Finally, campus facilities management faces high demands for sustainable development and long-term usability of buildings, such as energy efficiency and resource conservation.

These characteristics collectively make the facilities management phase a central focus, particularly for older buildings. This focus reflects not only the technical needs of aging infrastructure but also the strategic importance of campuses as hubs for cultivating future leaders, scientists, and engineers, as well as valuable institutional assets. However, despite this importance, campus facilities management often faces persistent challenges, including information silos, communication barriers, inefficient operations and maintenance, and a lack of effective digital management tools. In many cases, management still relies on traditional software such as Microsoft Word and Excel, without modern integrated systems or standardized processes. Maintenance management systems are largely corrective and cyclical in nature, lacking clear key performance indicators (KPIs) to optimize control functions (Ullah et al., 2019). Moreover, maintenance work is frequently driven by budget constraints rather than actual needs, leading to inefficient resource allocation. The inconsistent quality of outsourced maintenance and the complexity of reporting procedures further exacerbate these management challenges (Lateef et al., 2010).

2.3.3 BIM Applications in Public Building Management

Among all the solutions to the problem of large hospital building management, BIM is one of the most promising and mature theories (Hu et al., 2018). BIM provides a graphical platform with 3D building entities, and facilities managers can retrieve, analyze and process various data in a unified software interface (Gao & Pishdad-Bozorgi, 2019). Some successful cases have reported BIM-based facilities management (C. Moreno et al., 2019), and the energy management and safety management BIM platform is also well coordinated with the computer maintenance management system, which handles the basic activity records of daily maintenance (Peng et al., 2020).

In the absence of maintenance culture, an early warning system for damaged parts of public buildings is needed. Not only that, maintenance operations of public buildings should be carried out with appropriate skills, the required tools and environment should be created for effective maintenance processes, effective communication should be established with stakeholders, benchmarks should be provided for maintenance operations, early service and repair of damaged building parts should be ensured, user maintenance guides should be provided in maintained buildings, independent maintenance policies should be provided for the maintenance of public buildings, and effective decisions should be made in maintenance processes and operations (Ogunbayo et al., 2022). According to the above requirements, based on the core characteristics of BIM, it is suggested that BIM can be tried to solve it.

Regarding the issue of cultural heritage management of the public building of the Algeciras Market Hall, a public heritage management method based on BIM is proposed, considering the huge heritage infrastructure managed by some countries, which requires high economic expenditure every year. This makes it necessary to improve the traditional inspection and management system. This is a BIM method for preventive protection of public works heritage. It will be successful in the future management of most existing infrastructure assets. The most important benefit is the creation of digital records associated with models that are completely identical to reality, which helps to carry out maintenance processes according to the type of infrastructure we have (Bazán et al., 2021).

For the energy consumption problem in building management, Tu & Vernatha (2016) research to explore the application of building information modeling in the establishment of a "BIM-based energy management support system" (Tu & Vernatha, 2016). Managers can realize 3D visualization of space status in the BIM model, conduct real-time energy consumption analysis, compare the actual and standard energy consumption profiles of the space, and automatically detect anomalies in a space at a specific time of the day during the operation phase, conduct historical energy consumption analysis, review monthly and annual energy consumption profiles, and compare them with historical energy consumption profile.

In summary, similar or identical problems in campus facilities management can refer to the above solutions. It is not difficult to see that, in theory, BIM is feasible for campus facilities management, but its feasibility standards need to be further explored.

2.4 BIM Potential in Campus Facilities Management

2.4.1 BIM Benefits Across the Building Lifecycle

According to previous studies, BIM shows great potential advantages throughout the life cycle of a building, as shown in Figure 2.2. In the pre-construction stage, BIM can improve the accuracy of conceptual design and feasibility studies (C. Eastman et al., 2008), solve environmental and resource issues through site analysis (Azhar et al., 2011), and support conflict detection and energy consumption assessment. In the construction stage, BIM supports the analysis of complex building systems, optimizes resource planning and construction sequence through visualization of construction progress and cost (Kjartansdóttir et al., 2017), and improves the efficiency of component prefabrication (Enshassi et al., 2018). In the post-construction stage, BIM improves the sharing and decision-making capabilities of facilities operation and maintenance information. And further pointed out the three key contributions of BIM in this stage: facilities information delivery, operational efficiency improvement, and integration with FMS (C. Eastman et al., 2008). These advantages mean that using BIM for campus facilities management can significantly improve the overall quality and efficiency of management.

Phases	Benefits of BIM use
Pre-construction	• Better concept and feasibility (Eastman *et al.*, 2011) • Effective site analysis to understand environmental and resource-related problems (Azhar *et al.*, 2011b) • Improve effectiveness and accuracy of existing conditions' documentation (Kjartansdottir *et al.*, 2017) • Effective design reviews leading to sustainable design (Khosrowshahi, 2017) • Enhancement of energy efficiency (Eastman *et al.*, 2011) • Resolve design clashes earlier through visualizing the model (Latiffi *et al.*, 2016) • Enables faster and more accurate cost estimation (Khosrowshahi, 2017)
Construction	• Evaluation of the construction of complex building systems to improve planning of resources and sequencing alternatives (Kjartansdottir *et al.*, 2017) • Effective management of the storage and procurement of project resources (Eastman *et al.*, 2011) • Efficient fabrication of various building components offsite using design model as the basis (Enshassi *et al.*, 2018) • BIM allows better site utilization (Deshpande and Whitman, 2014) • Reduce site congestion and improve health and safety (Khosrowshahi, 2017)
Post construction	• BIM record model can help in decision-making about operations, maintenance, repair and replacement of a facility (Kjartansdottir *et al.*, 2017) • Makes asset management faster, more accurate and with more information (Husain *et al.*, 2014) • Ability to schedule maintenance and easy access to information during maintenance (Enshassi *et al.*, 2018)

Figure 2.2 Potential Benefits of BIM Adoption

Source: (Ullah et al., 2019).

2.4.2 BIM Applications in Campus Facilities Management

In fact, numerous cases have demonstrated the application of BIM in campus facilities management, confirming its advantages in this field. Table 2.1 and Table 2.2 present eleven such cases, summarizing the benefits and challenges of implementing BIM in campus facilities management.

Table 2.1 Related Case and Advantages

No.	Reference	Benefits
1	(Kassem et al., 2015)	Northumbria University City Campus in Newcastle upon Tyne uses BIM for facilities management to improve the performance of space management.
2	(Terreno et al., 2015)	Penn State University Multipurpose Stadium, applying BIM and FM integration to facilities management is effective and brings a tangible return
3	(Mcarthur, 2015)	Ryerson University's Kerr Building implements BIM for sustainable building operations.
4	(Bortolini et al., 2016)	UPC Terrassa Campus. BIM can lead to more rational energy use, reduced costs and increased asset value through maintenance and space management.
5	(Tu & Vernatha, 2016)	Taiwan University of China applies BIM for energy management.
6	(Galiano-Garrigós & Andújar-Montoya, 2018)	The renovation of the former Faculty of Education building of the University of Alicante has confirmed the feasibility and potential of implementing BIM in campuses, allowing for the optimization and acceleration of maintenance processes by obtaining more accurate information.
7	(Pavón et al., 2020)	The School of Civil Engineering of the Polytechnic University of Madrid (ETSICCP) provides a long-term development perspective with a management system based on BIM.
8	(J. V. Moreno et al., 2022)	The Civil Engineering Building of the Higher Technical School of Alameda in Lisbon, Portugal, developed a prototype of a BIM-based system to support the operation of the University building and obtain the latest environmental data.
9	(Q. Liu & Wang, 2022)	The use of Green BIM by a university library in northern China, Xi'an, Shanxi Province, China, highlights the importance of BIM technology in green building design and construction and its role in providing a standardized framework for the decision-making process and offering methods to improve the green performance of buildings.
10	(Desbalo et al., 2024)	Public buildings at three Universities in Addis Ababa, Ethiopia, implemented BIM, a key requirement for effective asset management. Not only could existing practices be improved, but overall performance could also be enhanced.
11	(Carrasco et al., 2024)	The Civil Engineering School at the University Cantabrian Santander "Las Llamas" campus in Spain has combined Geographic Information Systems (GIS) and BIM digital models to optimize operational efficiency and promote a collaborative environment, fundamentally changing building facilities management.

Source: Author's compilation based on various literature.

According to the above advantages of applying BIM in campus facilities management, we can see that compared with traditional campus facilities management methods, BIM has great advantages in facilities management, sustainable development and energy management in the operation and maintenance stage of campus facilities management. For example, a case study of Northumbria University in the UK showed that the application of BIM in facilities management significantly improved the accuracy of information transmission, the availability of data and the efficiency of order completion (Kassem et al., 2015). The renovation project of the University of Alicante in Spain further supported the application of BIM in campus maintenance, simplifying the maintenance process and reducing human errors through more complete information collection (Galiano-Garrigós & Andújar-Montoya, 2018). The case study of the Polytechnic University of Catalonia showed that the introduction of BIM can realize maintenance decisions and improve the efficiency of maintenance processes (López Zaldívar et al., 2017). In summary, BIM has indeed improved the efficiency of campus building facilities management and saved resources.

Table 2.2 Related Case and Challenges

No.	Reference	Challenges
1	(Kassem et al., 2015)	Covering technology compatibility, lack of standards, management fragmentation, insufficient resources, cultural barriers and benefit verification.
2	(Terreno et al., 2015)	Process management defects, social collaboration barriers, technical compatibility issues, cost control pressure
3	(Mcarthur, 2015)	Optimize data collection, cross-platform compatibility, and document management while balancing resource investment and model accuracy requirements
4	(Bortolini et al., 2016)	The data formats and data source formats are different, so the management software platform lacks standardization
5	(Tu & Vernatha, 2016)	Many technical issues of BIM-EMS still need to be studied, solved and implemented.
6	(Galiano-Garrigós & Andújar-Montoya, 2018)	Maintenance efficiency and productivity levels are low, and the maintenance system is not intelligent and digital enough.
7	(Pavón et al., 2020)	Technical compatibility, legal compliance and collaborative management
8	(J. V. Moreno et al., 2022)	The conflict between flexibility and standardization and the contradiction between manual dependence and technical shortcomings
9	(Q. Liu & Wang,	System transformation and management measures improvement
10	(Desbalo et al., 2024)	Data quality (collection, validation, standardization) and establishing a strategic information management framework
11	(Carrasco et al., 2024)	Issues with format compatibility and digital information integration

Source: Author's compilation based on various literature.

However, relevant challenges also come as expected. Through the analysis of 11 international cases, the main challenges faced when integrating BIM with other software proposed in different cases are summarized, including technical compatibility issues (such as cross-platform collaboration, inconsistent data formats, and difficulties in integrating digital information); management-level defects (such as lack of standards, decentralized processes, collaboration barriers, and legal compliance pressure); resource and cost constraints (such as insufficient investment, cost control pressure, and contradictions between model accuracy and resource balance); data governance problems (such as low data quality, insufficient verification and standardization, and integration of multi-source heterogeneous data); system intelligence shortcomings (such as low maintenance efficiency, insufficient digitalization, and conflicts between manual dependence and technical defects) and the trade-off challenge between standardization and flexibility. In addition, cultural barriers, benefit verification, and the establishment of a strategic information management framework are also considered key difficulties. These challenges, from the technical, management, and strategic levels, reflect the complexity of the BIM and software integration process.

2.5 The Application and Challenges of BIM in Malaysia

In Malaysia, the construction industry is one of the most important pillars of the economy, as it contributes to GDP growth and creates employment opportunities (Haddock, 2018). In recent years, BIM has been gaining more attention in the Architecture, Engineering, Construction and Operation (AECO) industry in Malaysia. Stakeholders such as designers, contractors and owners have recognized the advantages of BIM and started to use the technology to better manage and deliver projects (Latiffi et al., 2013). The Malaysian government has made it mandatory for all government projects worth more than 100 million Malaysian Ringgit to adopt BIM since 2018 (Dehdasht et al., 2022). In particular, the CIDB department continues to work hard to increase the adoption of BIM by stakeholders in the construction industry to improve the performance of the Malaysian construction industry at all levels of the supply chain. According to the Malaysia BIM report released in 2016, the adoption level of BIM was 17%. The adoption level in 2019 was 49%, a significant increase compared to 2016. And in 2021, the adoption level of BIM increased to 55%. The respondents' interest in establishing BIM has continued to increase from 2016 to 2021. This is due to the release of BIM guidelines and standards by the Malaysian government, which provide guidance and application standards for the application of BIM. The five major strategies to increase BIM adoption are: creating BIM training institutions to train young, fresh graduates, providing financial assistance to reduce the cost of adopting BIM, formulating BIM adoption guidelines, developing projects to integrate BIM into educational courses and academia and developing projects to increase BIM awareness and understanding (Construction Industry Development Board Malaysia, 2022).

With the support and guidance of government policies, the sustainability of campus development is becoming a key issue of concern to the Malaysian government. Because the Malaysian Ministry of Education has placed Malaysia on the map of higher education for foreign students, the education industry has expanded rapidly. Not only are more foreign universities opening local branches in Malaysia. And the number of students in local universities is also increasing year by year. Therefore, campus development issues should meet the growing needs of local and international students (Nifa et al., 2015). Universities used to rely on the Ministry of Education to send applications, but now they use their buildings as a variable to attract students (Laryea, 2008). The importance of campus facilities management is self-evident, and the development of campus is also inseparable from the important career of campus buildings. BIM may bring new opportunities for campus construction management in Malaysian universities, such as improving project efficiency and transparency, optimizing resource allocation and cost control, improving the quality and sustainability of campus facilities, and promoting collaboration between different departments.

Although the Malaysian government currently encourages BIM adoption through policy support, education, and training initiatives, the application rate in campus facilities management remains very low, with no widely recognized empirical cases. Insights from international experiences suggest that promoting BIM in Malaysian campuses will face multiple constraints, including the shortage of skilled BIM professionals and training opportunities, limitations in existing technical infrastructure, resistance to changes in organizational culture and management models, high initial investment costs, and the absence of unified standards and specifications.

2.6 Enablers of BIM Implementation

The effective implementation of BIM, however, depends on supportive conditions at multiple levels. Some studies have pointed out that the lack of unified data formats and interoperability standards will lead to obstacles in system integration and limit the value realization of BIM throughout the project life cycle (Khosrowshahi & Arayici, 2012). Therefore, technical infrastructure and data standardization are key prerequisites. In addition, the organization must have strategic leadership and management support. The digital vision of managers directly affects the promotion of BIM (Succar, 2009). At the personnel level, professional skills and BIM training systems are indispensable. Azhar et al. (2012) emphasized that employees tend to be cautious or resistant to BIM in the absence of proper training and motivation, which affects the efficiency of team collaboration(Azhar et al., 2012). Ghaffarianhoseini et al. (2017) further pointed out that when universities and other organizations introduce BIM, they also need to consider cultural adaptability and the construction of cross-departmental coordination mechanisms to deal with the conflict between existing management processes and BIM concepts (Ghaffarianhoseini et al., 2017). On the other hand, the policy and institutional environment constitute an important guarantee for the sustainable development of BIM. Multiple cases in Southeast Asia show that government-led policy support and standard promotion are accelerators for BIM implementation (Migilinskas et al., 2017). Finally, sufficient financial resources are also the basic guarantee for promoting BIM applications. The implementation of BIM involves software licensing, equipment upgrades and the construction of professional teams. If there is a lack of clear funding sources and long-term budget planning, the project will often be shelved (Nawari, 2018). Therefore, the feasibility of BIM implementation depends not only on tools and platforms, but also on comprehensive factors such as organizational governance capabilities, knowledge conversion mechanisms and environmental adaptability.

2.7 Research Gap

Although international cases: such as Northumbria University (UK), China University of Technology (Taiwan), and the University of Alicante (Spain), have demonstrated BIM’s potential in campus facilities management and energy analysis (Kassem et al., 2015;Tu & Vernatha, 2016; Bortolini et al., 2016). But most are technical demonstrations that do not systematically address management issues, implementation barriers, enabling conditions, and overall feasibility.

In the Malaysian higher education context, existing studies are scarce and mainly focus on technical performance or quantitative surveys, without investigating BIM from an internal management perspective that captures staff experiences and institutional readiness.

Furthermore, critical soft factors, such as interdepartmental coordination, cultural acceptance, and stakeholder engagement are often overlooked, despite their significant influence on BIM implementation success (Ghaffarianhoseini et al., 2017). This reveals a clear research gap: the need for a context-specific, qualitative assessment of BIM’s feasibility in campus facilities management within developing country universities, grounded in real operational challenges and organizational conditions. This study addresses this gap through an in-depth case study of UUM.

2.8 Chapter Summary

This chapter has systematically reviewed the development background, core features, and practical applications of BIM in the context of construction and facility management in Malaysia. Emphasis was placed on BIM's potential to enhance efficiency, support data integration, and enable collaborative management capabilities that are highly relevant for addressing the complex and systemic challenges found in campus facilities management.

The literature further highlighted key issues in current facility management practices within Malaysian universities, including fragmented information systems, limited resource allocation, and lack of digital integration. Despite various policy efforts to promote BIM adoption, challenges such as financial constraints, limited technical capacity, and inadequate institutional support continue to hinder its widespread implementation in the higher education sector.

Furthermore, this chapter identifies the necessary conditions for successful BIM adoption, including top management support, talent development, and strategic planning. These insights provide a conceptual foundation for evaluating the applicability of BIM in the specific context of UUM.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter aims to systematically explain the methodological framework adopted in this study to explore the feasibility of BIM in the facilities management of UUM campus buildings. Given that the research objective focuses on an in-depth understanding of current issues, potential solutions, and organizational acceptance, this study adopts a qualitative research method, combined with a case study strategy, to obtain first-hand data through semi-structured interviews, supplemented by NVivo software for systematic coding and thematic induction. This chapter will introduce the research design, case selection and interview process, data analysis methods, and the reliability, validity, and ethical assurance mechanisms of the research, as the basis for the empirical analysis in subsequent chapters.

3.2 Research Design

This study adopts a qualitative research design, aiming to identify the feasibility and potential obstacles of BIM in the facilities management of campus buildings by deeply exploring the practical problems in the UUM campus facilities management and its views on the application of BIM. Unlike quantitative research that focuses on causal verification, qualitative research focuses more on the construction of behavioral meaning in context and emphasizes the explanation of "how" and "why" questions (Creswell & Creswell, 2018). The philosophical stance is based on interpretivism, advocating that research should go deep into the cognitive world of participants and understand their work experience and institutional perception within the organization. UUM has not yet implemented BIM, and it is necessary to understand the similarities and differences in the cognitive levels of BIM between management and executives, so the interpretivist approach is particularly suitable. This study uses open coding to let the data "speak", summarizes structural themes in the analysis, and then judges the possibility of BIM application in the operation and maintenance management of campus building. To enhance the logical structure of the methodology, the study constructed the following research process model diagram (Figure 3.1):

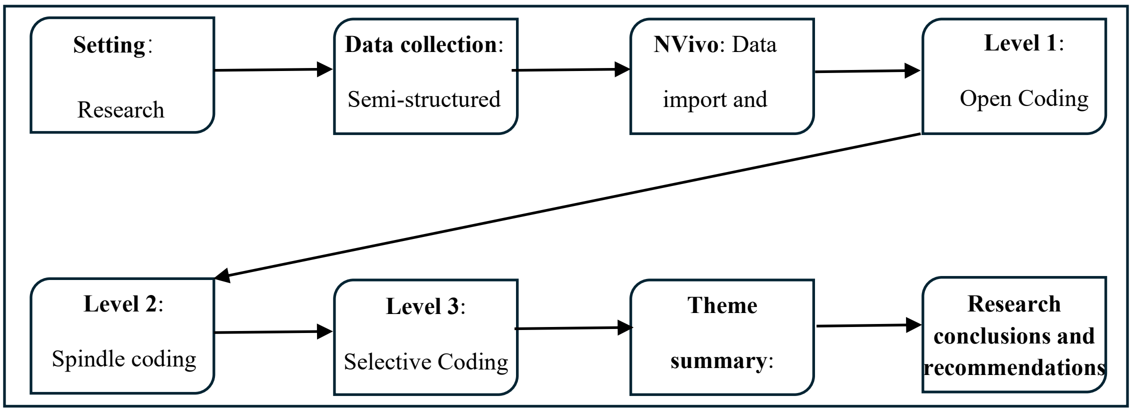

Figure 3.1 Research Process Model Diagram

Source: Author.

This flowchart shows the process of this study from problem setting, data collection to three-level coding based on NVivo, using the four-step method of open coding → axial coding → selective coding → theme induction to comprehensively refine the feasibility dimension. The system shows the complete path of this study from research problem setting to interview data analysis.

3.3 Case Study Strategy

To deeply analyze the real dilemma in the facilities management of campus building and the feasibility of implementation BIM, this study adopts a single-case embedded design, taking UUM as the main research unit and embedding representative employees of multiple sub-units (such as civil, mechanical, electrical and other departments) as data sources. The case study logic proposed by this strategy is in line with "when the research problem is realistic and the boundaries are blurred, case study is the most appropriate choice" (Yin, 2018). In addition, as a large public university that has not yet introduced BIM, UUM has a representative background, which is convenient for exploring management practices in real estate without organizational interference.

3.4 Sample Selection and Research Subjects

This study employs purposeful sampling to determine the sample of the survey subjects, ensuring that the research subjects possess relevant background knowledge and practical experience, and can provide in-depth and representative information. The sample selection focused on the personnel involved in the operation and maintenance of campus buildings, space management or facilities maintenance at UUM, mainly from the JPP department of the university. The organizational structure of the JPP department is shown in Figure 3.2:

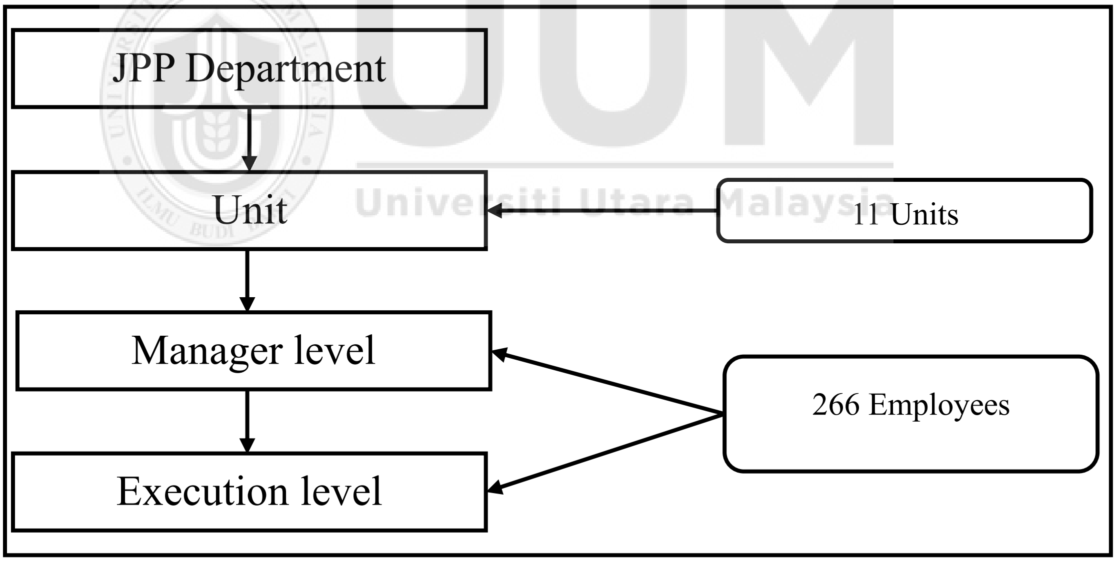

Figure 3.2 The Organizational Structure of the JPP Department

Source: Compiled by the author based on internal documents.

To ensure the representativeness of the departments and reflect diverse perspectives, the 12 respondents came from different departments of the JPP, including construction, civil engineering, mechanical engineering, quantity surveying and property management. As shown in Table 3.1, it outlines their positions and affiliations.

Table 3.1 Summary of Information on Interview Participants

Respondent ID	Unit	Position	Management Level	Years of Experience
JPP01	Civil Engineer Unit	Civil Engineer	Operational	2
JPP02	Contract Administration and Material Surveying Unit	Chief Quantity Surveyor	Managerial	24
JPP03	Contract Administration and Material Surveying Unit	Material Quantity Surveyor	Operational	2
JPP04	Architecture Unit	Architect	Operational	13
JPP05	Architecture Unit	Chief Architect	Managerial	18
JPP06	Architecture Unit	Architect	Operational	7
JPP08	Property and Facilities Unit	Senior Assistant Director	Managerial	9
JPP12	Mechanical Engineering Unit	Mechanical Engineer	Operational	3
JPP13	Electrical Engineering Unit	Electrical Engineer	Operational	6
JPP14	Electrical Engineering Unit	Chief Electrical Engineer	Managerial	31
JPP15	Mechanical Engineering Unit	Chief Mechanical Engineer	Managerial	18
JPP16	Electronic Engineering Unit	Chief Electronics Engineer	Managerial	18

Source: Developed by the Author.

And to achieve the research goals and gain cross-level perspectives, the 12 respondents covered different positions ranging from senior management to front-line technical and administrative levels. This multi-level sample structure helps to gain strategic and operational perspectives within the system and enhances the understanding of the adaptability and obstacles of BIM in actual management processes. The selection criteria for respondents include:

i. Having a certain number of years of practical experience in UUM building management.

ii. Directly participating in or cooperating with tasks related to building assets, space use, operation and maintenance processes.

iii. Having actual feelings and evaluation capabilities about the shortcomings and challenges of the current management system.

iv. Having the willingness and ability to express their own work experience and opinions.

Finally, in determining the sample size, this study followed the "information saturation" and "principle" commonly used in qualitative research. The saturation point is considered when the information provided by new respondents no longer leads to new topics or concepts (Guest et al., 2006). Relevant studies have pointed out that in semi-structured interviews with a focused theme and clear research questions, 12 respondents are usually sufficient to obtain the main information and reach saturation (Guest et al., 2006; Marshall et al., 2013). Especially in case studies within the organization, if the respondents all come from key positions in the target system, their work experience and expertise can better ensure the quality and depth of the collected data (Palinkas et al., 2015). Therefore, the sample size and structure selected in this study not only conform to the theoretical basis of the research method but also consider the feasibility of practical operation and the need for research quality control, laying a solid foundation for subsequent in-depth data analysis.

3.5 Data Collection Procedure

Data collection was conducted through semi-structured in-depth interviews, with English or Malay as the language of choice for the interviewees. Each interview lasted approximately 30 minutes and was fully recorded with the informed consent of the interviewee. All interview recordings were transcribed and translated into English for subsequent systematic coding analysis using NVivo software. The interview design was based on open-ended questions, considering both guidance and flexibility to ensure the depth and breadth of the data (Kvale, 2007).

3.6 Interview Outline Design

This study designed the interview outline with reference to relevant literature. Although the research contexts and stages of these studies differed from the present research, their discussions on multi-dimensional obstacles to BIM implementation, technical adaptation, and policy environment provided valuable guidance (Khosrowshahi & Arayici, 2012). In addition, the structure and wording of the interview questions were refined by drawing on methodological recommendations (Rubin & Rubin, 2012), ensuring logical coherence, clarity of expression, and alignment between the question flow and the academic objectives of this study.

To ensure content validity and contextual relevance, the interview guide was reviewed and approved by the research supervisor, who is an academic expert in construction and facilities management. Minor revisions were made based on his feedback to improve clarity and alignment with the research objectives.

The final version of the interview outline consists of 12 open-ended questions, categorized into five thematic sections as shown below (Table 3.2):

Table 3.2 Interview Questions Outline

No.	Interview Questions
1	Key issues in current campus facilities management.
2	Information transmission and collaboration.
3	The cognition and application value of BIM.
4	Barriers to implementing BIM.
5	Support conditions and suggestions.

Source: Developed by the Author Based on (Khosrowshahi & Arayici, 2012) .

3.7 Data Analysis Methods

This study used NVivo software for systematic coding analysis. Based on the theoretical coding framework (Corbin & Strauss, 2015). The data analysis was divided into the following three stages:

i. **Open Coding:** Analyze all interview texts sentence by sentence to extract initial concepts and keywords.

ii. **Axial Coding:** Integrate related concepts into thematic categories.

iii. **Selective Coding:** Identify the core relationship between the axes, form a comprehensive structure, and finally derive the judgment logic of BIM feasibility.

To enhance the analytical rigor and transparency, NVivo was utilized to generate visual representations such as node frequency charts, coding trees, and attribute cross-tabulations, which helped illustrate coding patterns and differences across respondent groups. The entire coding process adhered to principles of iteration and constant comparison to ensure analytical depth and consistency.

3.8 Chapter Summary

This chapter systematically explains the methodological approach adopted by this study in exploring the feasibility of BIM, covering research design, sample strategy, data collection and NVivo three-stage coding analysis method. By combining embedded case studies with open interviews and supplemented by systematic data analysis tools, the depth and reliability of the research were effectively improved. The research flow chart also helps to clarify the logical framework and provide a solid empirical basis for subsequent research results and analysis.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the main findings of the study, which is derived from the interview data of 12 staff members in the UUM JPP department. A three-stage coding method is adopted: open coding, axial coding and selective coding. The system analyzes the data to extract key topics. The content of the sub-chapters corresponds to the research questions and objectives, covering current management issues, causes, problems solved by BIM, implementation challenges and supporting conditions. These thematic dimensions provide a structured basis for evaluating the feasibility of BIM in the operation and maintenance management of UUM campus buildings. The selected encoding framework is shown in Figure 4.1:

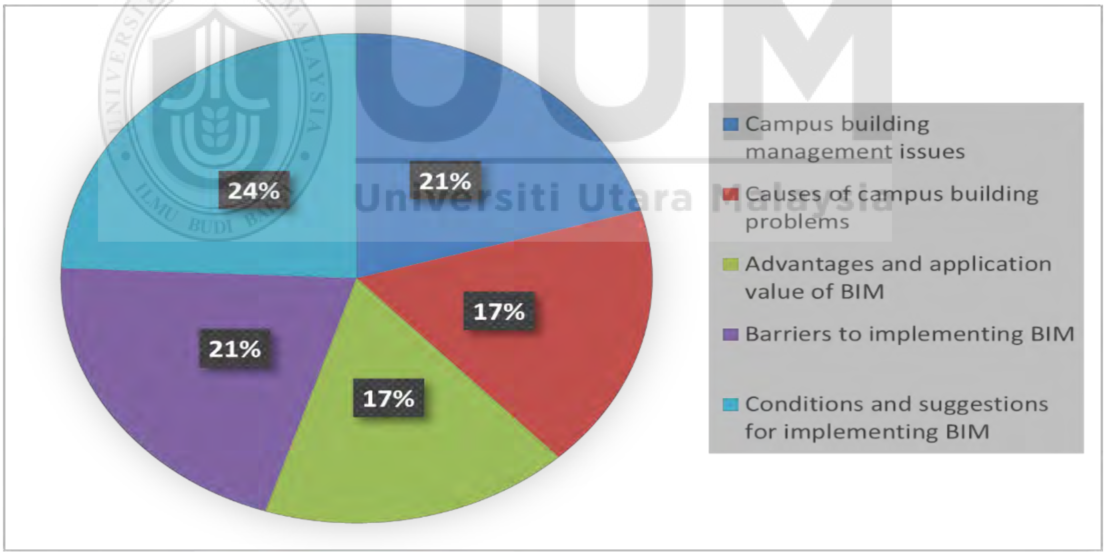

Figure 4.1 Selective Coding Proportion

Source: Compiled by the author based on interview data.

According to the distribution of themes in the interview coding results, the ratios of conditions and suggestions for implementing BIM (24%), campus facilities management issues (21%), and barriers to implementing BIM (21%) all exceeded 20%. These data provide the basis for the feasibility criteria.

4.2 Case Background

This study selects UUM as the case analysis object, mainly based on its typicality in organizational structure and management context. UUM is the sixth largest public university in Malaysia, with a history of over 40 years. The total area of its campus exceeds 10 million square meters, and the building types cover multi-functional areas such as teaching, administration, accommodation and leisure. The buildings are large in volume and diverse in type, and the management tasks are complex, reflecting the common problems faced by higher education institutions in Malaysia in campus facilities management.

The campus facilities management of UUM is coordinated by the JPP, which consists of multiple functional units covering professional fields such as civil engineering, electrical engineering, mechanical engineering, architecture, contract and customer service. This study conducted on-site research and interviewed 12 JPP employees from different functions and management levels to obtain first-hand data from multiple dimensions such as management decision-making, daily operation and maintenance, and project execution, ensuring the diversity of perspectives and the depth of the data. The interviewees were closely involved in the daily operations of the site and were familiar with its practical context, which ensured that the data collected accurately reflected the real conditions of campus facilities management.

4.3 Key Issues in Campus Facilities Management

Based on the coding of the interview data, the main problems currently faced by the campus facilities management of UUM are obtained. The analysis results revolve around six key themes. The specific situation is shown in the following Table 4.1:

Table 4.1 Current Management Issues Coding Content Table

Axial Coding	Open Coding	Respondent ID
Current system issues （44%）	**FM system defects** (58%) - Insufficient functional coverage (44%) Unable to meet requirements (29%) Low FMS automation (15%) Low FMS operation efficiency (12%) Good FM system maintenance and management (23%) **Other system problems** (19%) - System fragmentation (64%) No centralized information processing system (18%) No professional software for design and cost management (9%) Microsoft project-lack of value number (9%)	JPP-01 JPP-02 JPP-04 JPP-06 JPP-08 JPP-12 JPP-13 JPP-14 JPP-15 JPP-16
Operational management issues （19%）	Insufficient preventive maintenance (30%) Facilities need to be updated (23%) High maintenance workload (20%) Maintenance work is limited by budget (10%) Buildings are not centrally managed (10%) Insufficient energy management (7%)	JPP-01 JPP-02 JPP-04 JPP-05 JPP-06 JPP-08 JPP-12 JPP-13 JPP-14 JPP-16
Organizational communication and coordination issues （18%）	Information communication is delayed inaccurate (57%) cross-departmental collaboration is complex (21%) There is no perfect coordination system (11%) Third-party management is difficult (11%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-06 JPP-08 JPP-12 JPP-13 JPP-15 JPP-16
Funding issues （9%）	Insufficient maintenance budget (86%) Cost pressure (14%)	JPP-01 JPP-02 JPP-04 JPP-12 JPP-13 JPP-14 JPP-16
Spatial planning management issues （8%）	Insufficient public space capacity (59%) Insufficient classroom capacity (33%) Inadequate building planning (8%)	JPP-04 JPP-08
Project Management Issues （2%）	Risk of not delivering on time (75%) Application project is subject to budget constraints (25%)	JPP-02 JPP-15

Source: Developed by the Author.

According to the NVivo coding results, the most prominent issues in the current campus facilities management of UUM include, in order: existing system issues (44%), operation and maintenance management problems (19%), and organizational communication and coordination obstacles (18%), which are widespread in the actual management experience of the surveyed employees, reflecting the core challenges of the current management system in handling daily business and resource coordination.

Firstly, at the system level, respondents generally pointed out that the existing FMS has insufficient functional coverage, a low degree of automation, and low information processing efficiency, making it difficult to meet the diverse management needs of various units within the JPP department. The system relies heavily on manual operation, resulting in process lag and response delay, which affects the overall operational efficiency. A respondents pointed out: “Currently, the FMS system needs to collect the student report content first and then report it to the FMS, which leads to a long response time” (JPP13). Although some respondents said that “the maintenance and management function of FMS is not bad”, these opinions are merely an endorsement of the system’s maintenance information management function. The overall system performance is still not satisfactory. Therefore, overall, the current FMS has significant problems in terms of applicability and scalability. This is highly consistent with the management issues such as “fragmentation of information systems” and “lack of an integrated platform” pointed out in Chapter 1. Literature also points out that the fragmentation and incompatibility of information systems are one of the main obstacles to enhance collaborative management capabilities (Khosrowshahi & Arayici, 2012).

Secondly, in terms of operation and maintenance management, the main problems include the lack of preventive maintenance strategies, severe aging of facilities, and a large amount of maintenance work but insufficient manpower and budget. The chief electronic engineer of the JPP department stated, "Currently, the FMS system does not have the capability for preventive maintenance" (JPP16). This reflects the current "passive" approach that mainly focuses on post-event repair. The maintenance mechanism is unable to cope with the complex operational demands of campus buildings, hindering the systematic and proactive development of operation and maintenance work. As mentioned in Chapter 1, higher education institutions in Malaysia generally face practical predicaments such as outdated facilities and low management efficiency.

Thirdly, problems in organizational communication and coordination are widespread in cross-departmental collaboration, including delayed information transmission, weak feedback mechanisms, and unclear boundaries of responsibilities. Since JPP involves multiple technical units internally and lacks a unified process and coordination mechanism, the response to problems is slow and the execution efficiency is low. This once again confirms the description in Chapter 1 regarding the decentralized organizational structure and unclear management processes.

In addition, the issue of budget constraints (9%) is also very crucial. Literature indicates that the shortage of funds is a significant obstacle hindering the deployment of BIM and digital management technologies (Ghaffarianhoseini et al., 2017). The mechanical engineer mentioned such a situation: "Due to insufficient budget, we can only selectively maintain" (JPP12). The insufficiency of spatial planning (8%) and the weakness of project management (2%) also reflect from the side the lack of data support and intelligent tools, further exposing the shortcomings of system construction. The phenomena of low space utilization efficiency and imbalance in the allocation of teaching spaces and public spaces are particularly prominent against the backdrop of the coexistence of old and new buildings. An architect emphasized: “Nowadays, our management departments do not advocate building new buildings but rather hope that we do a good job in spatial planning” (JPP04). This uneven utilization of space indicates the lack of comprehensive spatial data visualization and planning support mechanism, and this is precisely the key link where BIM can intervene and optimize (Succar, 2009a).

To sum up, the problems currently faced by UUM in campus facilities management are typically multi-dimensional and systematic. Weak links have been exposed at all levels, from the system platform, daily operation and maintenance to resource coordination and execution mechanisms. These problems are common in actual management, reflecting the difficulties faced by the current management system in daily business processing and resource coordination.

4.4 The Causes of Problems

Based on the above problems, it can be seen from the selective coding results in Table 4.2 that the main problems of UUM campus facility management are caused by the following factors: backward technology (39%), time factors (23%), financial constraints (16%), human factors (11%), and a small number of natural resources, space planning and organizational structure problems.

Table 4.2 Current Problem Causes Coding Content Table

Axial Coding	Open Coding	Respondent ID
Insufficient management technology （39%）	**Insufficient current system functions** (52%) - Single FMS maintenance function (45%) Lack of digitization (automation) (30%) Lack of automatic fault monitoring mechanism (11%) Lack of 3D tools (7%) Lack of construction management and measurement software (7%) **Still using traditional methods** (48%) - Using manual methods (40%) Backward technological development (16%) Manual inspection (12%) Working in traditional ways (12%) Traditional methods are inefficient (12%) Working in Excel (8%)	JPP-01 JPP-03 JPP-04 JPP-05 JPP-06 JPP-08 JPP-12 JPP-13 JPP-15 JPP-16
Time Factor （23%）	Aging buildings (61%) Aging facilities (39%)	JPP-01 JPP-04 JPP-05 JPP-06 JPP-12 JPP-13 JPP-16
Financial factors （16%）	Dependence on government funding (52%) Insufficient maintenance budget (24%) Irrational budget allocation (14%) The government does not have multiple financial plans (10%)	JPP-01 JPP-02 JPP-04 JPP-06 JPP-08 JPP-13 JPP-16
Human Factors （11%）	Human maintenance errors (36%) Aging staff (22%) Inadequately motivated staff (21%) Large campus population (14%) Lack of planning (7%)	JPP-05 JPP-06 JPP-08 JPP-15 JPP-16
Natural resource factors （6%）	Climate Rainy season and flooding	JPP-01 JPP-05
Space planning factors （3%）	Many scattered buildings	JPP-01 JPP-05 JPP-08 JPP-16
Organizational structure factors （2%）	Outsourcing of maintenance work (75%) Unclear response mechanism (25%)	JPP-01 JPP-08 JPP-16

Source: Developed by the Author.

Firstly, the lack of management techniques is the primary cause of the current problem. The current FMS system has a single function, limited to corrective maintenance information management, and lacks cross-departmental data sharing, three-dimensional visualization, and full life cycle management capabilities. Meanwhile, some processes still rely on manual operations and traditional tools (such as Excel and paper spreadsheets), resulting in information duplication, untimely data, and low decision-making efficiency. As one respondent put it: "We are still scheduling on paper, and the efficiency is very low" (JPP02). These problems are widespread in the actual management experience of the employees interviewed, reflecting the core challenges of the current management system in handling daily business and resource coordination. It is also pointed out in Chapter 1 that the management of facilities in Malaysian universities generally has problems such as low digitalization and inconsistent information systems, which seriously hinder the process of modern intelligent management.

Secondly, the frequent maintenance and operational pressures caused by the aging of buildings and equipment (due to time factors) have further exacerbated the shortage of human and material resources. Many campus buildings have been in use for over 40 years and are in a "post-repair" state, which is inefficient, costly, and prone to recurring problems, directly affecting the continuity of teaching and administrative activities. This point also precisely corresponds to the issue mentioned in Chapter 1 that "the aging of facilities in colleges and universities is widespread and the maintenance cycle lacks forward-looking management". As Azhar et al. (2012) stated: "If buildings lack full life cycle management supported by digital tools in the later stage of use, it will be difficult to achieve forward-looking maintenance and optimal allocation of resources" (Azhar et al., 2012).

Thirdly, fiscal factors limit management autonomy and flexibility. Maintenance of UUM facilities relies heavily on government grants, with budgets lacking flexibility and rationality. Delayed or insufficient funds interrupt renewal plans, and in the long term, “limited resources must meet unlimited demands”. The respondents expressed helplessness over “insufficient maintenance funds”, noting that the main source is allocations from the government’s education department. This is a common issue among public universities in Malaysia (JPP02). Such a fiscal structure is a major obstacle to digital transformation, restricting the adoption of technologies like BIM.

Fourthly, human factors cannot be ignored, such as maintenance errors, insufficient staff incentives, and inadequate human resource planning. Employees generally lack a proactive awareness of inspections, leading to delayed responses. This is also partly due to the lack of intelligent monitoring and information tracking systems. Furthermore, while issues related to the natural environment, spatial distribution, and organizational structure were mentioned less frequently, their systemic impact cannot be ignored. For example, the dispersed distribution of buildings increases inspection costs and makes information collection difficult, while seasonal flooding also complicates management.

In summary, the management challenges facing UUM campus building facilities management are not caused by a single factor; rather, they represent a systemic obstacle formed by the accumulation of multiple factors, including technology, personnel, systems, time, and resources. The existing management model is no longer able to support the complex demands of campus buildings throughout their entire lifecycle, with their high-density information and collaborative decision-making.

4.5 The Problems Solved by BIM

Respondents generally expressed high recognition for BIM's capabilities in intelligent management, operations and maintenance, project management, and asset management. BIM demonstrates promising application prospects, particularly in addressing current issues in UUM campus building and facility management, such as "outdated technology", "insufficient staff", "tight budgets", and "low collaboration efficiency". This is shown in Table 4.3.

Table 4.3 BIM Advantages and Application Value Coding Table

Axial Coding	Open Coding	Respondent ID
Intelligent management （23%）	BIM-3D visualization (27%) BIM-system integration and interaction (27%) BIM-data integration (20%) BIM-intelligence (13%) BIM-multidisciplinary integration (10%) BIM-intelligent safety system (3%)	JPP-01 JPP-03 JPP-05 JPP-06 JPP-08 JPP-12 JPP-13 JPP-15 JPP-16
Operation and maintenance functions （22%）	BIM-facilitates facilities maintenance management (48%) BIM-energy management (38%) BIM-information management (7%) Better decision-making (4%) More efficient (3%)	JPP-01 JPP-03 JPP-05 JPP-06 JPP-08 JPP-13 JPP-16
project management （21%）	BIM-reduces errors and conflicts (26%) BIM-controls schedule (19%) BIM-saves money (15%) BIM-optimizes design (11%) BIM-saves resources (11%) BIM-improves construction management (7%) BIM-provides technical support (7%) BIM-plans projects in advance (4%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-12 JPP-13 JPP-14 JPP-15 JPP-16
BIM-application value recognition （14%）	Can bring benefits (36%) Can do a lot of things (22%) Very powerful (21%) Believe it will be indispensable in the future (14%) Can be used (7%)	JPP-03 JPP-04 JPP-05 JPP-08 JPP-15 JPP-16
Asset management capabilities （13%）	BIM-full cycle application (53%) BIM-space management (35%) BIM-asset management (6%) BIM-beneficial to project development (6%)	JPP-01 JPP-03 JPP-04 JPP-05 JPP-08 JPP-13 JPP-16
Organization and coordination management （4%）	BIM-Coordination Function (100%)	JPP-01 JPP-05 JPP-12 JPP-13 JPP-16
Planning Management （2%）	BIM-Campus facilities management (100%)	JPP-03 JPP-04 JPP-14

Source: Developed by the Author.

Firstly, in terms of intelligent management (23%), BIM's powerful information integration and 3D visualization capabilities provide support for the comprehensive perception and coordinated management of building assets, which is significantly superior to the current FMS system's problems of single function and data fragmentation. As a financial manager pointed out: "BIM covers all stages of a project from development to operation, while FMS is limited to daily maintenance" (JPP03). The system integration function of BIM also helps to break down information silos among units and lay the foundation for cross-departmental collaboration (C. Eastman et al., 2008).

Secondly, operation and maintenance functions (22%), BIM's preventive maintenance and energy management capabilities have enhanced management proactiveness, broken the post-maintenance deadlock, and responded to the problems of facilities aging and lagging maintenance. As one engineer mentioned: "BIM can accurately locate leakage points in the early stage, which is difficult to achieve with traditional methods" (JPP01).

Thirdly, the application of BIM in project management (21%) helps to address issues such as "schedule delays", "resource waste", and "design conflicts" existing in the construction of UUM campus. Through multi-disciplinary integration and virtual construction simulation, BIM can enhance on-site coordination and construction accuracy, optimize cost and schedule control, which corresponds one-to-one with the causes of the "project management bottleneck" problem in Section 4.3. As the respondents pointed out: "BIM is very beneficial for project development and can avoid unnecessary material waste" (JPP15).

In addition, in terms of asset and space management (13%), BIM supports the full life cycle management of space and facilities, achieving precise tracking and scheduling, improving resource utilization, and alleviating the problems of “chaotic spatial layout” and “difficult asset positioning”. This highlights the direct advantages of BIM in addressing the difficulties of asset positioning and the opacity of resource information.

Although there are fewer references to organizational coordination management (4%) and planning functions (2%), all mentions point to the fact that BIM can improve multi-departmental collaboration and workflow transparency through model sharing mechanisms, form a unified communication platform, and solve the problems of overlapping responsibilities and poor information feedback (Khosrowshahi & Arayici, 2012).

Finally, in the perception of the application value of BIM (14%), mostly respondents generally recognized the long-term value of BIM (such as “bringing benefits” and “powerful functions”). Although a few respondents still had doubts about its maintenance of application adaptability, the overall perception trend was positive, indicating that UUM initially established a cognitive foundation for the implementation of BIM at the organizational level.

4.6 Barriers to Implementing BIM

Although respondents generally believe that BIM can provide solutions to current problems and has great potential in improving the management efficiency of campus building facilities and promoting intelligent operations. However, further exploration has also exposed a series of practical obstacles and limiting factors. This study, through selective coding analysis of respondents' opinions, has summarized the following six types of challenges and limiting factors faced by BIM implementation, as shown in Table 4.4.

Table 4.4 Obstacle Code Table for Implementing BIM

Axial Coding	Open Coding	Respondent ID
Funding Challenges （34%）	BIM-high cost (42%) BIM-lack of relevant funds (33%) BIM-expensive hardware and software (25%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-06 JPP-08 JPP-13 JPP-14 JPP-15 JPP-16
Human Resources Challenges （19%）	Insufficient professional talent (37%) Lack of BIM training for employees (20%) Insufficient manpower (20%) Lack of BIM expertise (13%) Current employees have a heavy workload (10%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-06 JPP-13 JPP-14 JPP-15 JPP-16
Challenges within the organization （17%）	**Management lacks understanding of BIM** - Not much (68%) Think it is new knowledge (20%) Heard of it (8%) Management lacks technical background (4%) **Lack of management support**	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-06 JPP-08 JPP-12 JPP-13 JPP-14 JPP-15 JPP-16
Not applicable type （11%）	Not suitable for small, simple projects (60%) Not suitable for old buildings (40%)	JPP-01 JPP-04 JPP-06 JPP-13 JPP-14 JPP-16
Technical Challenges （10%）	Modeling challenges (47%) Requirement for multidisciplinary collaboration (33%) Lack of software and hardware (20%)	JPP-01 JPP-06 JPP-12 JPP-13 JPP-16
Not many practical applications （9%）	There is currently a lack of practical applications (80%) BIM is not widely popular (13%) There are no BIM professional courses (7%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-13

Source: Developed by the Author.

These restrictive factors essentially reflect that the basic conditions, organizational capabilities and cognitive levels of current campus facilities management are not yet fully equipped with the strategic and technical support required for BIM implementation. This is closely related to the insufficient system functions, human factors and organizational management reasons analyzed above.

Firstly, the financial challenge (34%) was regarded by most respondents as the most critical limiting factor. This includes high costs in aspects such as BIM software licensing, hardware equipment procurement, and subsequent operation and maintenance. Especially under the fiscal structure where universities generally rely on government grants and the approval process is lengthy, the lack of flexible special budget arrangements makes BIM investment difficult to sustain. This issue not only hinders the initial pilot deployment of BIM but also restricts its long-term strategic deployment in the full life cycle management of campus assets. Therefore, the extended payback period in the initial stage of BIM implementation is often cited as a major factor contributing to organizations' reluctance to adopt it (C. Eastman et al., 2008).

Secondly, the challenges in human resources (19%) are equally significant, reflected in the shortage of professional talents, insufficient skill reserves of employees, and the lack of a systematic training mechanism, etc. Data shows that most of the current managers of UUM lack BIM operation experience and have a heavy workload, making it difficult for them to spare time for effective learning and adaptation. One executive mentioned, "We do not have ready-made employees, so we must train them to ensure they possess the skills needed to implement BIM" (JPP01). Without a mature talent pool and channels for enhancing capabilities, the promotion of BIM is highly likely to fall into the predicament of "having tools but no people".

Thirdly, insufficient cognitive and management support within the organization (17%) is another key constraint. Most managers still have a superficial understanding of BIM, considering it “novel but complex”, and have insufficient recognition of its strategic value in facilities management. This situation has led to a lack of a unified promotion mechanism within the organization, furthering the implementation of BIM. This is highly consistent with the problems of “weak coordination mechanism” and “unclear organizational structure” described in Section 4.4. It also meets the prerequisite that “the promotion of BIM requires organizational consensus and institutional coordination” (Succar, 2009a).

In addition, some respondents pointed out that there are many simple-structured or old buildings on campus at present, lacking modeling data, which leads to a low cost-effectiveness of BIM implementation. Meanwhile, issues such as complex modeling, difficulty in multi-disciplinary collaboration, and insufficient technical support have also increased the difficulty of implementation. In addition, BIM in colleges and universities still lacks mature application cases and reference templates, and the course coverage is limited, which leads to it remaining at the theoretical level and making it difficult to form a virtuous cycle from pilot to promotion, further weakening the confidence in promotion within the organization.

To sum up, the current obstacles for UUM to promote BIM are not confined to a single technical or operational level but rather stem from systematic incompatibility in multiple aspects such as institutional mechanisms, resource allocation, capability structure, and cognitive foundation. These obstacles are highly consistent with the background of the problems raised in Chapter 1 and the description of the predicament of BIM application in developing countries in the literature of Chapter 2. The success of BIM is not only the introduction of technology, but also the transformation of the organizational management model (Migilinskas et al., 2017).

4.7 Conditions for Implementing BIM

Based on data coding analysis, the supporting factors for BIM implementation can be divided into five categories. These factors form the key foundation for the feasibility of BIM application and form a logical closed loop with the above sections. As shown in Table 4.5:

Table 4.5 Support Condition Coding Table for Implementing BIM

Axial Coding	Open Coding	Respondent ID
Need human resources support （31%）	Need to train employees (44%) More staffing (23%) Employees need BIM expertise (17%) Hire specialized talent or team (16%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-06 JPP-08 JPP-13 JPP-14 JPP-15 JPP-16
Existing application intention and behavior （26%）	Recommended to management to apply for BIM (25%) Applied for relevant funds (10%) Communicated with external parties for learning (15%) Already had similar experience (13%) Moving towards BIM (12%) Already formed a BIM team (10%) Planned to establish a BIM laboratory (5%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-06 JPP-08 JPP-13 JPP-14 JPP-15 JPP-16
Need support from managers （19%）	School senior management support (50%) Need policy support (20%) **Need cognitive support** (20%) - [Need senior management cognitive support (57%)] [Improve awareness of BIM advantages (43%)] Need government promotion (10%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-05 JPP-08 JPP-13 JPP-15 JPP-16
Need financial support （14%）	BIM-obtains relevant budget (100%)	JPP-01 JPP-02 JPP-03 JPP-04 JPP-06 JPP-08 JPP-13 JPP-14 JPP-15
Need technical support （5%）	BIM-software and hardware support (100%)	JPP-01 JPP-06 JPP-08 JPP-16

Source: Developed by the Author.

Firstly, human resource support (31%) is regarded as the most crucial supporting condition. Most respondents clearly pointed out the need to enhance employee training, create new positions and introduce specialized talent teams, indicating that there is already a cognitive foundation within the organization and an initial awareness that the human resource structure needs to be optimized in tandem with the BIM transformation.

Secondly, the application willingness and behavior (26%) indicate that some units have recommended that their management introduce BIM, or have proactively learned from external institutions, and even have plans to establish BIM teams and laboratories. This indicates that although UUM is still in its early stage, some departments have already adopted a positive attitude of "from trial to action", providing practical soil for subsequent implementation.

In addition, management support (19%) is also a key factor in success or failure. Respondents emphasized the need for cognitive support and policy promotion from the top management. More than half of them believed that the management's awareness of the advantages of BIM should be enhanced, which indicates that the transformation of organizational culture is closely related to the attitude of top leadership. Literature also indicates that the strategic orientation and policymaking of the leadership play a core role in guiding and allocating resources during the implementation of technology (Gu & London, 2010).

In terms of resources, although the current proportion of financial support (14%) and technical support (5%) is relatively low, there is a consensus that "software and hardware support" and "obtaining special budgets" are the basic prerequisites for the implementation of BIM. Therefore, establishing systematic financial planning and IT support mechanism is a key supplement to enhancing execution capabilities.

To sum up, in the process of promoting the application of BIM in campus facilities management, UUM, despite facing multiple obstacles, also has certain endogenous support conditions, especially in terms of the transformation of people's consciousness, the willingness to try, and the budding of management support.

4.8 BIM Feasibility Theme Summary

Based on the above coding structure and in combination with the induction path set during the research process, the feasibility analysis standards for BIM implementation were further refined and integrated into five major feasibility theme dimensions (Table 4.6)：

Table 4.6 Five Major Thematic Dimensions

Thematic dimension	Related spindle code	High frequency open coding	Number of ID	Typical citation content
System adaptability	Current system function limitations Current system problems	FMS- Single maintenance function FMS system defects System fragmentation	11	The main for FS now is focused on maintenance so cannot control other stage.
Management Improvement Drive	Space planning management issues Project management issues Operation management issues Organizational communication and coordination issues	Insufficient information public space capacity Information communication is delayed, and inaccurate Cross-departmental collaboration is complex. Buildings are not centrally managed	12	For now, we have limited space. Because the capacity does not cater to that. Basically.
Organizational willingness to accept	BIM-application value recognition Existing application intention and behavior	Recommended to management to apply for BIM Applied for relevant funds Benefits of BIM	12	because before we already talked to the top management to do BIM, but we asked for the software fund. For software fund for new warrant of staff so we do not have enough money.
Capacity and resource guarantee	Need human resources support Need management support Need financial support Need technical support	Need to train staff Need to support from school management Need to have budget	11	if we use BIM, we need to use, firstly we need to use more time to be training staff.
Strategy promotion mechanism	High-level awareness Promotion and publicity	Senior-level understanding and support Professional lectures or seminars Pilot projects are gradually promoted	12	We provide an example of a project that tries to use BIM technology and then analyze it to see if it was successful. We can then apply the learnings to other projects.

Source: Developed by the Author.

Through further integration and summarization of the open codes and key nodes, the study identified five key feasibility dimensions that influence UUM's BIM implementation: system adaptability, management improvement drives, organizational acceptance, capacity and resource guarantees, and strategic advancement mechanisms. These dimensions represent the challenges and prerequisites faced across five levels: technical system support, management process optimization, personnel attitudes and cognition, resource and capacity foundations, and organizational strategic advancement.

In terms of system adaptability, the existing FMS system has limited functionality, primarily focused on maintenance management, and struggles to cover the full lifecycle of building management. It also suffers from technical shortcomings such as data fragmentation and low system integration. Management improvement drivers are currently manifested in inadequate spatial planning, delayed information transfer, complex cross-departmental collaboration, and a lack of centralized management, all of which hinder management efficiency and decision-making support. While organizational acceptance has initially emerged, with some employees and management recognizing the value of BIM and proposing its introduction, constraints remain in funding and software procurement. Capacity and resource assurance emphasize the human, technical, managerial, and financial support required for BIM implementation, particularly regarding training time and budget, which present key obstacles to implementation. Finally, the strategic promotion mechanism focuses on high-level awareness and support, systematic promotion and training, and the promotion and application of pilot projects, which will directly impact the widespread adoption and sustained implementation of BIM in campus building management.

Overall, these five thematic dimensions are both independent and interrelated, forming a feasibility framework for UUM's BIM implementation. Technical systems and resource capabilities are the foundation, management improvements and organizational commitment are the driving forces, and strategic advancement mechanisms guarantee long-term success. By strengthening the supporting conditions in each dimension, UUM can establish a digital campus building management system covering the entire lifecycle, improving information integration, operational efficiency, and scientific decision-making, thereby achieving a modern transformation in campus facility management.

4.9 Chapter Summary

This chapter presented a comprehensive analysis of the qualitative data derived from the semi-structured interviews, systematically addressing the five major thematic dimensions influencing the feasibility of BIM implementation at UUM: system Adaptability, management Improvement Drive, organizational Willingness to Accept, capacity and Resource Guarantee, and strategic Promotion Mechanism. The findings revealed that each dimension encapsulates specific technical, managerial, organizational, and strategic factors that either support or hinder the adoption of BIM in campus building management.

Through the integration of open coding and axial coding, it was found that technical limitations of the current FMS, fragmented information systems, inadequate space planning, and complex cross-departmental coordination remain critical barriers. At the same time, the emerging recognition of BIM's value, coupled with targeted management improvements and the potential for high-level strategic support, provide a foundation for future implementation. The analysis also highlighted that adequate human, financial, and technical resources are prerequisites for successful adoption, and that pilot projects and structured promotion can serve as effective mechanisms for organizational change.

Furthermore, the response frequency analysis from the perspective of different positions (Figure 4.2) revealed notable variations in the emphasis placed on each thematic dimension. Positions such as architects and civil engineers demonstrated the highest frequency of references, suggesting a broader and more integrated awareness of BIM-related issues. In contrast, positions with a narrower technical scope showed lower engagement on some topics, reflecting differences in their day-to-day responsibilities and management challenges.

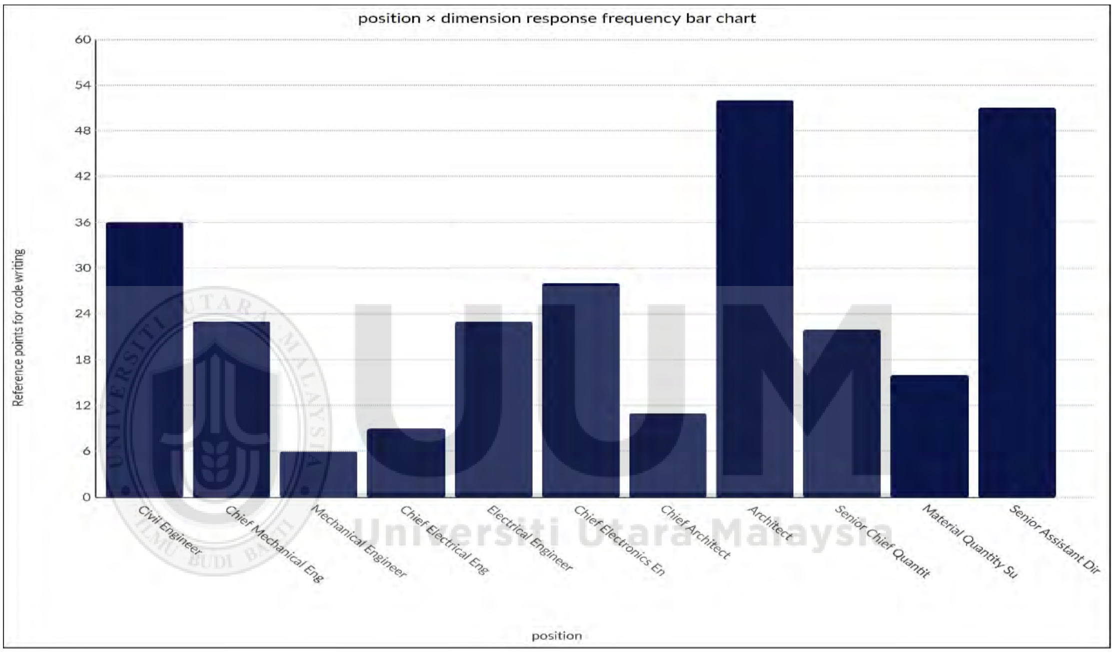

Figure 4.2 Response Frequency for Different Positions

Source: Compiled by the author based on interview data.

Overall, this chapter has constructed a multi-dimensional BIM application feasibility framework within the context of UUM. The findings indicate that overcoming technological limitations, aligning organizational commitment, ensuring adequate resources, and integrating BIM into the institutional strategic agenda are key prerequisites for transforming campus facilities management into a fully integrated, lifecycle-oriented digital platform. This suggests that, when these conditions are met, BIM implementation is realistically feasible within a UUM, providing a solid empirical foundation for the targeted recommendations presented in the next chapter.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Research Summary

This study addressed the five research objectives through NVivo-based qualitative analysis, verifying both the theoretical and practical potential of BIM in the operation and maintenance management of UUM campus buildings, and identifying the key prerequisites for its successful implementation. A qualitative case study approach was adopted, combining semi-structured interviews with NVivo coding and thematic analysis to systematically examine the existing problems, underlying causes, and the potential applications of BIM within the campus facilities management context.

By conducting open, axial, and selective coding, the research distilled five critical dimensions influencing BIM adoption: system adaptability, management improvement drive, organizational willingness to accept, capacity and resource guarantee, and strategic promotion mechanism. Analysis of these dimensions confirmed that BIM is conditionally feasible for UUM's campus building management. This feasibility is supported by respondents shared recognition of the need for system upgrades, their positive perception of BIM's collaborative capabilities, and the existence of preliminary enabling conditions at the management and resource levels.

Although challenges remain, the findings indicate that with targeted strategic planning and adequate resource investment, BIM holds substantial practical potential for effective adoption. This study not only fills a research gap in the application of BIM for campus facilities management within the Malaysian higher education sector but also offers a reference framework for other institutions seeking to advance towards fully integrated, lifecycle-oriented digital campus management.

5.2 Research Findings

Building upon the thematic analysis presented in Chapter 4, this section summarizes the key findings that highlight the primary challenges influencing the feasibility of BIM implementation at UUM.

i. Fragmented departmental structures and inadequate communication mechanisms lead to delayed responses and reduced coordination efficiency.
ii. Insufficient financial and human resources result in reactive maintenance practices and hinder the sustainability of long-term operations.
iii. Scattered and non-digitalized asset and facilities data limit preventive maintenance and evidence-based strategic planning.
iv. Aging, building stock and reliance on outsourced maintenance services create challenges in ensuring accountability and service quality.
v. The absence of an integrated digital management platform restricts centralized control, real-time monitoring, and cross-functional collaboration.

5.3 Research Contributions

Theoretical Contribution: This study advances BIM scholarship by providing an in-depth qualitative examination of its conditional feasibility in campus facilities management, a context rarely addressed in Malaysian higher education. It enriches existing theory by integrating management, organizational, and policy dimensions into feasibility analysis, offering a holistic framework that connects technical capabilities with institutional readiness.

Practical Contribution: The findings deliver an actionable mapping between UUM's facility management challenges and corresponding BIM functions, such as centralized data integration, lifecycle maintenance coordination, and space utilization optimization. This mapping serves as a decision-making tool for university administrators, enabling them to align BIM adoption strategies with available resources, organizational culture, and policy frameworks, thus improving the success rate of digital transformation initiatives.

5.4 Recommendations for Implementing BIM

Based on the respondents' promotion suggestions (Figure 5.1) and the specific context of UUM, this study proposes seven practical recommendations for advancing BIM implementation in campus facilities management:

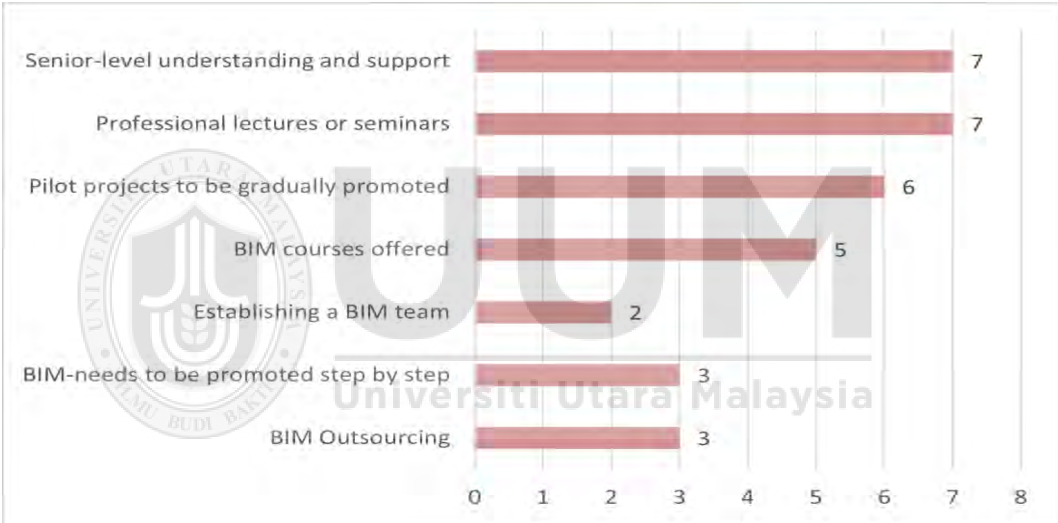

Figure 5.1 The Frequency Chart of Respondents' Promotion Suggestions

Source: Compiled by the author based on interview data.

i. **Enhance senior management awareness and support**: Interview data highlight that the awareness and commitment of senior management are regarded as the primary condition for BIM adoption (mentioned by 7 respondents). It is recommended that UUM organize dedicated briefings or arrange visits to BIM practice cases at domestic and international universities. This will enable the management to understand BIM's strategic value and incorporate it into the institutional reform agenda for campus facilities management, thereby promoting the coordination of policies, budgets, and resources.

ii. **Initiate BIM pilot projects with gradual expansion:** To address the lack of practical experience, newly constructed or recently renovated campus buildings should be prioritized as BIM pilot projects (suggested by 6 respondents). Adopting a "pilot first, then expand" approach can validate BIM's adaptability and benefits on a smaller scale, while developing UUM specific standards and templates for wider application.

iii. **Strengthen systematic capacity building:** BIM talent reserves and operational skills within UUM remain limited. Capacity building should include Regular professional lectures and skills training for JPP managers (7 respondents). Integration of BIM modules into architecture and engineering curricula to equip students with application skills. Partnerships with external institutions to access certified training resources and establish a sustainable talent pool.

iv. **Establish a BIM coordination team:** Although few units currently have BIM teams, it is recommended that UUM establish a cross-functional BIM coordination group, led by JPP, responsible for standard setting, model management, system integration, and training organization. This team should be proficient in BIM software operation and capable of providing both coordination and technical support.

v. **Adopt a phased deployment strategy:** Given the diversity of UUM's building stock, including old, dormitory, and teaching buildings BIM deployment should be phased and categorized by service life and functional importance. Priority should be given to new, complex function buildings with complete data for full modeling, while older buildings may adopt outsourced or simplified modeling to control costs and improve efficiency.

vi. **Promote cross-departmental collaboration mechanisms:** The functional divisions within JPP are highly specialized, but inter-departmental communication barriers persist. Establishing an information-sharing platform and collaborative workflows can break down data silos, clarify responsibilities across design, construction, and operation stages, and maximize BIM's collaborative advantages.

vii. **Secure budget support and resource guarantees:** BIM implementation requires stable funding sources. UUM should allocate a dedicated BIM fund within its annual budget, seek external funding from agencies such as the Ministry of Education and CIDB, and explore partnerships with BIM vendors to alleviate internal financial pressures.

Collectively, these recommendations directly address the enabling conditions identified in this study's feasibility framework, particularly strategic promotion, capacity and resource guarantees, and organizational willingness, reinforcing the conclusion that BIM adoption in UUM is conditionally feasible when these measures are implemented.

5.5 Study Limitations

Although this study has provided a comprehensive assessment of the feasibility of BIM implementation in the UUM context, several limitations should be acknowledged:

i. **Scope of the sample**: The respondents were drawn exclusively from specific units within UUM (e.g., JPP), and their perspectives may not fully represent those of the wider higher education sector or other universities with different organizational structures.

ii. **Nature of the data**: The findings are based on qualitative interviews, which are influenced by the participants' subjective understanding and articulation. This limits the ability to quantify the actual performance gains or cost–benefit outcomes of BIM adoption.

iii. **Absence of post-implementation evidence**: As BIM has not yet been implemented at UUM, the study evaluates "potential applications" rather than actual operational outcomes and thus lacks empirical before-and-after comparisons to validate the projected benefits.

These limitations suggest that future research could incorporate a broader and more diverse sample base, adopt mixed methods approaches to triangulate qualitative insights with quantitative performance metrics, and conduct longitudinal case tracking once BIM implementation is initiated.

5.6 Future Directions

To address the above limitations and enhance the applicability of the findings, future research may proceed in the following directions:

i. Conduct cross-university comparative studies to explore how differences in organizational culture and funding structures influence BIM implementation outcomes.
ii. Integrate quantitative approaches, such as questionnaire surveys and performance evaluation models, to verify and quantify the effectiveness of BIM adoption.
iii. Track the implementation process of BIM pilot projects and develop a data model and experience framework based on stage-by-stage evaluations.
iv. Investigate integration strategies between BIM and other campus information systems (e.g., IOT, smart energy platforms) to achieve comprehensive digital management.

Pursuing these directions would not only validate and refine the feasibility framework proposed in this study but also provide a stronger evidence base for guiding BIM adoption in campus facilities management across the Malaysian higher education sector.

5.7 Conclusion

This study focuses on campus facilities management at UUM, employing field interviews and systematic coding analysis to reveal deficiencies in the traditional management model in terms of functions, information, processes, and collaboration, and to assess the conditional feasibility of introducing BIM in this context. The findings indicate that, under the assurance of strategic guidance, capacity building, and sustained management commitment, BIM has the potential to significantly enhance intelligent management, achieve information integration, and optimize lifecycle facilities management. This conclusion not only provides an implementation reference for UUM but also extends the theoretical boundaries of BIM feasibility research in the context of universities in developing countries, while offering practical guidance for advancing the digital transformation of campus facilities management.

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