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EXPLORING THE CHALLENGES OF IMPLEMENTING DIGITAL TWIN IN FACILITIES MANAGEMENT IN MALAYSIA

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Abstract — Digital twin technology in facilities management (FM) provides substantial advantages, including predictive maintenance, real-time asset monitoring, and improved decision-making. Nevertheless, the implementation of digital twins in Malaysia's facilities management sector remains constrained, mainly due to various implementation challenges. This study aims to explore these problems using a quantitative analysis derived from a survey of FM managers in Klang Valley, Malaysia. A total of 49 questionnaires received were analysed using descriptive analysis in SPSS version 23. The results identified key challenges, including the digital twin's technology limitation, high hardware and software costs, and financial limitations. Addressing these issues is critical for successfully adopting digital twin technology, which can ultimately enhance FM practices in Malaysia.

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1.0 INTRODUCTION

FM encompasses the coordination of a broad array of services and resources to ensure that built environments remain functional, comfortable, and safe. FM's goal is to bring together "people, place, and process within the built environment to make life better and the core business more productive" [1]. Wetzel and Thabet [2] point out that FM involves many different people, which makes tasks like finding the right facility spaces, keeping FM records, and managing data from many different systems more difficult. Traditional FM methods, which often rely on manual processes, are susceptible to various inefficiencies, including high error rates, time and cost inefficiencies, and data loss [3]. These challenges complicate the role of FM managers in ensuring buildings perform well for both owners and tenants [4].

The introduction of Building Information Modelling (BIM) is to solve these inefficiencies in FM, offering significant advantages during the building project's FM phase [5]. BIM technology can be extended to 6D and 7D models, which incorporate aspects of FM, asset management, and sustainability [6]. However, despite its use in FM, BIM has limitations: It is not made to respond to operational needs in real-time and primarily focuses on the building structure rather than the people within it [7]. This emphasis differs from FM's objective of integrating people, place, and process [1].

The growing need for real-time monitoring and responsive management has steered advancements from BIM to digital twin technology. Digital twins provide real-time, two-way integration between cyber and physical systems and facilitate intelligent decision-making [8]. Research indicates that advanced digital twin technologies have significantly improved BIM and FM integration [4]. Digital twins provide insights into the current condition of subsystems, the impact of occupant behaviour, potential asset failures (such as HVAC or lighting issues), and other critical data [7].

Despite the well-documented benefits of digital twins [7,8,9], their adoption in Malaysia's FM sector remains slow. The industry continues to rely on conventional methods for building operations and maintenance, resulting in inefficiencies and data loss. One primary obstacle is the lack of digitisation processes, which restricts data accessibility [10]. This paper aims to explore the obstacles that impede the adoption of digital twins in Malaysia's FM sector. Through a quantitative approach utilising a questionnaire, this research seeks to identify obstacles and propose solutions that benefit FM utilising a questionnaire, this research seeks to identify obstacles and propose solutions that benefit FM by paving the way for successful digital twin adoption.

1.1. The Overview of Facilities Management in Malaysia

FM is a term that carries various definitions and interpretations across the globe. The International Organisation for Standardisation [1] says that FM is "an organisational role that brings together people, places, and processes in the built environment to make life better for individuals and the main business more efficient." According to The International Facilities Management Association (IFMA) [11] describes FM as the coordination of diverse interdisciplinary activities within the built environment and managing their impacts on people and workplaces. Likewise, Atkin and Brooks [12] define FM as a comprehensive approach to operating, maintaining, enhancing, and adapting an organisation's facilities and infrastructure, with the goal of creating an environment that supports the organisation's primary objectives effectively.

The fundamental values of FM can be categorised into three distinct areas: (1) optimising the performance of facilities, (2) improving the experience of facility users within the specific built environment, and (3) fostering a sustainable built environment [1]. The primary focus of the FM profession is to assist individuals. It involves ensuring that buildings are efficient, functional, sustainable, safe, and pleasant for people to live and work in, as well as maintaining a comfortable surrounding environment. This role also makes the operations of organisations easier and establishes an environment in which all systems work together smoothly.

FM in Malaysia has evolved significantly over the past few decades, reflecting the country's infrastructure and built environment development. The role of technology in FM is another critical area of focus. Adopting advanced technologies is necessary for enhancing efficiency and effectiveness in FM practices. However, the Malaysian FM industry has been slow to embrace technological advancements, which hampers its growth potential [13]. The present FM industry continues to employ conventional methods for building operation and maintenance, resulting in inefficiency and significant information loss due to insufficient digitisation processes that render data unavailable [10].

1.2. Digital Twin in Facilities Management

Digital twin technology has become increasingly influential in FM, providing cutting-edge solutions for monitoring, managing, and optimising building operations throughout their lifecycles. Digital twins are real-time digital replicas of physical assets, allowing stakeholders to simulate, analyse, and enhance facility performance [14]. These digital models integrate various technologies, such as the Internet of Things (IoT), Building Information Modelling (BIM), and Artificial Intelligence (AI), creating a robust and comprehensive facilities management framework. By leveraging real-time data from sensors and IoT devices, digital twins enable ongoing monitoring and predictive analytics, which are critical for informed decision-making in FM [15,16]. For example, the integration of IoT with digital twins allows for extensive data collection on building operations, facilitating analyses that can boost energy efficiency, improve occupant comfort, and optimise overall building performance [17,18]. In healthcare settings, this capability is particularly valuable, as digital twins can enhance resource allocation and patient care through real-time data insights [16,18].

Digital twins also play a crucial role in lifecycle management, supporting the planning, design, construction, and operational phases of a facility [15,19]. A systematic review by Hakimi et al. [8] found that digital twins help connect theoretical ideas with real-world uses in FM, which leads to a more unified way of managing a facility's lifecycle. This integration is critical to navigating the complexities of modern buildings, which often involve numerous systems and stakeholders. For instance, using digital twins in energy management systems has led to substantial gains in efficiency and sustainability [17, 20].

However, the implementation of digital twins in FM is not without obstacles. Challenges such as data interoperability issues, the integration of legacy systems, and the need for standard protocols can complicate

deployment [19,21]. Additionally, shifting from traditional FM practices to a digital, twin-based model requires significant investments in technology and workforce training, which can be a barrier for some organisations [21]. The literature underscores that overcoming these challenges is crucial for fully realising the benefits of digital twins in FM and ensuring their broader adoption [21,22].

1.3 Challenges in Digital Twin Implementation

Utilising digital twins in FM presents many challenges that must be addressed to harness its full potential. This literature review synthesises key issues identified in recent studies, focusing on technology limitations, high hardware and software costs, financial constraints, data synchronisation, preparation for adoption, exposure and awareness, data safety and security, lack of proof of usage, and resistance to change. The detailed potential challenges of implementing digital twins in FM are as follows:

1.3.1. Technology Limitations

Digital twin technology, despite its potential, has considerable technological limitations. The combination of real-time data with current systems often proves challenging, as many current tools do not fully embody the digital twin concept, instead functioning as digital models or shadows [23]. The complexity of accurately modelling physical assets and processes can hinder effective implementation, particularly in industries with intricate operational frameworks [24]. Furthermore, the reliance on advanced hardware and software components complicates the deployment of digital twins, as these systems require seamless data flow and integration capabilities [25].

1.3.2. High Cost for Hardware and Software

The financial implications of adopting digital twin technology are substantial. Initial capital expenditures (CAPEX) for necessary hardware and software can be prohibitive, particularly for smaller organisations [26]. The return on investment (ROI) is contingent upon the successful planning and deployment of supportive infrastructure, which can further escalate costs [27]. Studies indicate that companies often struggle to justify these expenses without clear, demonstrable benefits from digital twin implementations [24].

1.3.3. Financial Limitations

Beyond the initial costs, ongoing financial limitations pose a barrier to the widespread adoption of digital twins. Organisations may lack the financial flexibility to invest in the continuous updates and maintenance required for these systems [27]. The financial burden is exacerbated by the need for skilled personnel to manage and operate digital twin technologies, which can lead to additional training and hiring costs [28].

1.3.4. Data Synchronisation

The successful operation of digital twins heavily depends on effective data synchronisation. The main challenge is ensuring that the digital model accurately mirrors real-time changes in the physical asset [24]. Poor data integration can cause inconsistencies, which may compromise the digital twin's reliability and lead to ineffective decision-making [29]. Additionally, data fragmentation across multiple systems complicates synchronisation, requiring strong data management strategies [30].

1.3.5. Preparation to Adopt

Preparation for adopting digital twin technology involves not only technical readiness but also organisational change management. Companies must cultivate a culture that embraces innovation and is willing to adapt existing processes to integrate digital twins effectively [24]. This preparation phase often requires significant time and resources, which can discourage organisations from pursuing implementation [31].

1.3.6. Exposure and Awareness

A lack of exposure and awareness regarding the benefits and functionalities of digital twins can hinder their adoption. Many stakeholders remain uninformed about the potential applications and advantages of digital twin technology, which leads to scepticism and reluctance to invest [28]. Educational initiatives and case studies

demonstrating successful implementations are essential to raise awareness and foster acceptance within the FM industry [23].

1.3.7. Data Safety and Security

Data safety and security concerns are paramount when implementing digital twins, particularly in sectors handling sensitive information. The integration of digital twins with existing systems increases vulnerability to cyber threats, necessitating robust security frameworks [32]. Organisations must prioritise the development of secure data handling protocols to protect against potential breaches that could compromise both the digital twin and the physical assets it represents [33].

1.3.8. Lack of Proof of Usage

The absence of substantial proof of successful digital twin implementations can deter potential adopters. Many organisations are hesitant to invest in technologies that lack a proven track record, particularly when the benefits are not immediately apparent [24]. Case studies and empirical evidence demonstrating the effectiveness of digital twins in various applications are crucial to building confidence among stakeholders [28].

1.3.9. Unwillingness to Change

Finally, resistance to change remains a significant barrier to the adoption of digital twin technology. Organisations often exhibit a reluctance to alter established processes and workflows, which can impede the integration of innovative technologies [24]. Overcoming this inertia requires strong leadership and a clear vision of the benefits that digital twins can bring to FM [31].

2.0 METHOD

This paper seeks to investigate the challenges associated with implementing digital twin technology in the FM sector within Malaysia's Klang Valley. To meet this objective, a quantitative research method was used, involving a questionnaire survey. The survey was conducted between March 2024 and May 2024, gathering responses from 49 participants, which equates to a 61% response rate. The survey specifically targeted facilities managers. The questionnaire was divided into three parts: the first covered demographic information, the second addressed challenges related to digital twin implementation, and the final section allowed for open-ended comments. In the second section, nine items were used to evaluate the obstacles to adopting digital twin technology in the Malaysian FM industry. Responses were measured on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The collected data were analysed using descriptive analysis in SPSS version 23, and the results were ranked and presented in tables.

3.0 RESULTS AND DISCUSSION

3.1. Demographic Profile

The study had 49 participants, resulting in a response rate of 61%. As noted by Baldauf et al. [34] and Hager et al. [35], research conducted in organisational settings typically yields lower response rates, with 15% often considered acceptable for such surveys. Therefore, the response rate in this study is deemed justifiable. Table 1 presents the demographic profile of the respondents.

Table 1 Demographic Profile

Item	Description	Frequency	Percentage
Education Background	Master's Degree	13	26.5
	Bachelor's Degree	36	73.5
Experience	Less than 1 year	9	18.4
	1 to 5 years	23	46.9
	5 to 10 years	14	28.6
	More than 10 years	3	6.1

3.1.1. Educational Background

Educational background was the first question asked in the questionnaire. Out of the 49 respondents who participated in the survey, 26.5% (13) hold a master's degree, and 73.5% (36) hold a bachelor's degree. Figure 1 shows the distribution of educational backgrounds among the survey respondents.

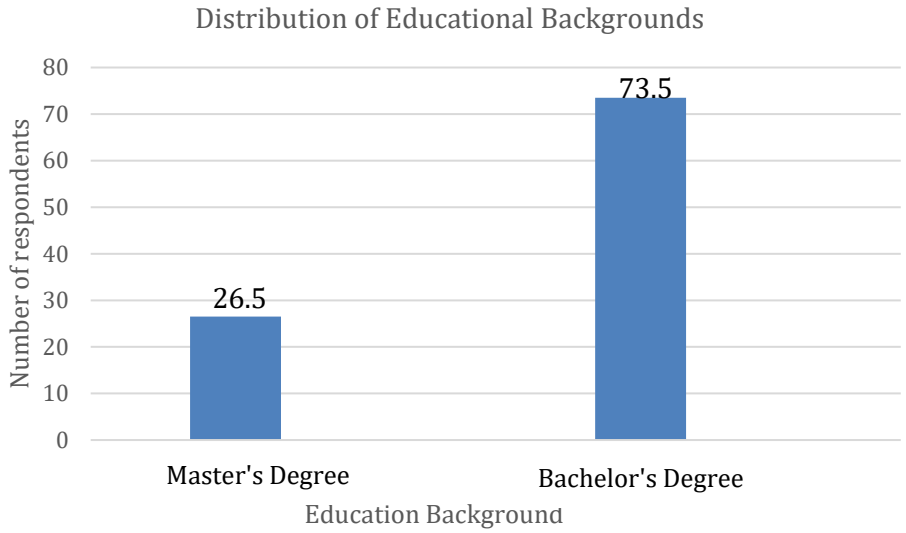


Figure 1 Respondents' education background

3.1.2. Work Experience

Meanwhile, in terms of work experience, 18.4% (9) have less than 1 year of experience, 46.9% (23) have 1-5 years of experience, 28.6% (14) have 5-10 years, and 6.1% (3) have more than 10 years of experience. The demographic profile shows that the respondents are highly qualified to answer the questionnaire. Figure 2 illustrates the breakdown of respondents' experience.

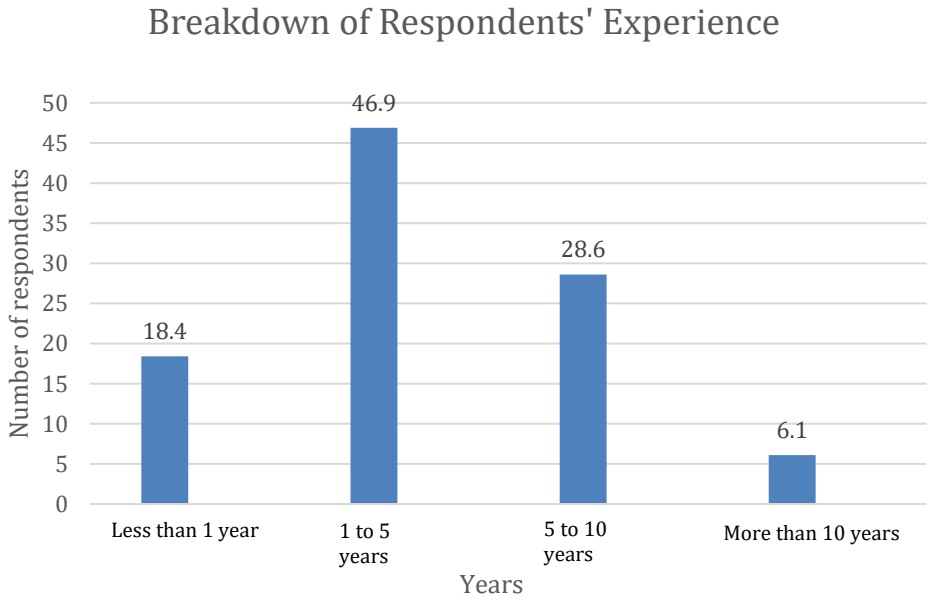


Figure 2 Respondents' experience

3.2. Challenges of Digital Twin Implementation

Nine (9) challenges of digital twin implementation in FM based on the literature review have been analysed using descriptive analysis. The results of the analysis, as illustrated in Table 2 below, show the mean score for each variable. The result shows that (i) technology limitations (M=4.35), (ii) high cost for hardware and software (M=4.20), (iii) financial constraints (M=4.12), (iv) data synchronisation (M=3.92), (v) preparation for adoption (M=3.82), (vi) exposure and awareness (M=3.78), (vii) data safety and security (M=3.73), (viii) lack of proof of usage (M=3.57), and (ix) unwillingness to change (M=3.55). The average mean value is 3.89. This indicates that all factors are essential.

Table 2 Challenges of Digital Twin Implementation

Challenges	**N**	**Mean**	**Std. Deviation**
Technology limitation of digital twin	49	4.35	0.805
High cost for hardware and software	49	4.20	0.912
Financial limitations	49	4.12	0.949
Data synchronisation	49	3.92	0.932
Preparation to adopt	49	3.82	0.882
Exposure and awareness	49	3.78	1.066
Data safety and security	49	3.73	1.095
Lack of proof of usage	49	3.57	1.137
Unwilling to change	49	3.55	1.100
Average Mean Score		**3.89**	

Based on the data analysis presented in Table 2, it was determined that there are nine (9) primary challenges of implementing a digital twin in the Malaysian FM industry. For brevity, only three (3) challenges are discussed due to high mean scores. The following are the top three (3) main challenges of implementing a digital twin in the Malaysian FM industry.

3.2.1. Technology Limitations

The majority of those who participated in the survey agreed that the “technology limitations" may impede the implementation of digital twins. The mean score is 4.35. One of the primary challenges is the current technological constraints of digital twin systems. These include the limited capabilities of existing hardware and software to manage the vast amounts of data and real-time simulations required for digital twins. The need for advanced sensors, IoT devices, and high-performance computing platforms to accurately mirror the physical environment places a significant strain on current infrastructure. Moreover, the complexity of integrating various subsystems within a facility, such as HVAC, lighting, and security, into a unified digital model remains an ongoing challenge, especially when existing systems were not designed with digital twin integration in mind.

3.2.2. High Cost of Hardware and Software

The second challenge is the “High Cost of Hardware and Software”, with a mean score of 4.20. The cost of implementing digital twins is prohibitive for many organisations, particularly those that are smaller or financially constrained. The initial capital outlay for hardware, such as sensors and network infrastructure, can be substantial. The challenge is further compounded by the cost of software solutions, which require sophisticated platforms for data processing, visualisation, and real-time analytics. These systems also demand ongoing maintenance and updates to ensure accuracy and functionality. As a result, many facilities are deterred by the high upfront and operational expenses associated with digital twin technology despite the potential long-term benefits in efficiency and cost savings.

3.2.3. Financial Limitations

The variable "Financial Limitations" has a mean score of 4.12, making it the third variable with a high mean score. Beyond the direct cost of technology, broader financial limitations also play a role in the slow adoption of digital twins. Facility managers often operate with tight budgets that prioritise immediate needs over long-term investments in advanced technology. This issue is particularly acute in industries with thin margins, and the return on investment (ROI) from digital twins may not be immediately apparent. Furthermore, the cost-benefit analysis for digital twin implementation can be complex, requiring a nuanced comprehension of how operational efficiencies, predictive maintenance, and lifecycle management might offset the initial expenditures.

4.0 CONCLUSION

The study highlights several significant challenges impeding the adoption of digital twin technology in Malaysia's FM industry. The key barriers identified include the digital technology limitation, the high hardware and software cost, and financial limitations, posing substantial hurdles for FM organisations. Overcoming these obstacles requires concerted efforts in data collection, technological upskilling, and cost-effective integration strategies. Furthermore, addressing these challenges will foster the broader adoption of digital twin technology, driving more efficient and predictive FM operations. Ultimately, by embracing this technology, FM organisations in Malaysia can enhance decision-making, reduce costs, and improve facility lifecycle management.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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