IMPROVING BUILDING INFORMATION MODELLING (BIM) IN TECHNICAL VOCATIONAL EDUCATION AND TRAINING (TVET) IN MALAYSIA POLYTECHNICS

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by

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PENAMBAHBAIKKAN PERMODELAN MAKLUMAT BANGUNAN (BIM) DALAM PENDIDIKAN DAN LATIHAN TEKNIKAL DAN VOKASIONAL (TVET) DI POLITEKNIK MALAYSIA

ABSTRAK

Kajian ini meneliti berkaitan penambahbaikkan Permodelan Maklumat Bangunan (BIM) dalam Pendidikan dan Latihan Teknikal dan Vokasional (TVET) di Politeknik Malaysia, dengan memberi fokus khusus pada kursus Diploma Seni Bina, Kejuruteraan, dan Pembinaan (AEC). Objektif kajian ini adalah untuk menilai secara kritikal penggunaan BIM ke dalam kurikulum TVET, menilai tahap kesedaran pendidik terhadap BIM, mengenalpasti halangan yang dihadapi, serta mencadangkan strategi untuk memperkukuhkan pendidikan BIM di politeknik-politeknik Malaysia. BIM telah memainkan peranan penting dalam industri AEC, penerapannya dalam kurikulum TVET di Malaysia menghadapi pelbagai halangan yang ketara, termasuk ketiadaan pendekatan yang seragam, kekurangan sumber, dan jurang dalam kemahiran BIM secara praktikal dan teori dalam kalangan pendidik terutamanya di Politeknik Malaysia. Meskipun topik ini telah mendapat perhatian, penyelidikan yang memberi tumpuan khusus kepada pendidikan BIM dalam konteks pendidikan tinggi di Malaysia, namun masih belum memadai. Kajian ini menggunakan metodologi kuantitatif, melalui soalselidik yang komprehensif bagi mengumpul data mengenai demografi pendidik, tahap kesedaran terhadap BIM, dan halangan dalam pelaksanaannya. Dapatan kajian menunjukkan bahawa 50% pendidik hanya memiliki kemahiran BIM pada tahap sederhana, dan sebilangan besar tidak mempunyai kelayakan yang mencukupi dalam bidang ini. Kajian ini telah memberi penekanan terhadap keperluan bagi pembangunan kurikulum yang berterusan, penambahbaikan

kerangka kerja terhadap pendidikan BIM yang sediada, dan penambahbaikkan halangan yang menghalang keberkesanan terhadap pendidikan BIM. Strategi yang dicadangkan termasuk meningkatkan pengetahuan BIM dalam kalangan pendidik, memastikan akses kepada perisian terkini, dan mengintegrasikan bengkel praktikal ke dalam kurikulum. Kesimpulannya, dengan mengiktiraf tahap kesedaran BIM yang pelbagai dan menangani cabaran yang telah dikenalpasti, kajian ini membuka jalan untuk penambahbaikan yang ketara dalam kualiti dan relevansi terhadap pendidikan BIM di institusi TVET terutama bagi politeknik-politeknik di Malaysia, selaras dengan keperluan landskap teknologi yang berkembang pesat di negara ini.anda.

IMPROVING BUILDING INFORMATION MODELLING (BIM) IN TECHNICAL VOCATIONAL EDUCATION AND TRAINING (TVET) IN MALAYSIA POLYTECHNICS

ABSTRACT

This study investigates the Building Information Modelling (BIM) in Technical Vocational Education and Training (TVET) in Malaysia Polytechnics, particularly for the Diploma in Architecture, Engineering, and Construction (AEC) courses. The objectives are to critically assess the improvement of BIM in the TVET curriculum, evaluate educators' awareness of BIM, identify the barriers encountered, and propose strategies to enhance BIM education in these institutions. Despite BIM's critical role in the AEC industry, its implementation within the Malaysian TVET curriculum faces significant obstacles, including the absence of a standardised approach, limited resources, and gaps in both practical and theoretical BIM expertise among educators. While the subject has garnered attention, research specifically addressing BIM education within the context of Malaysian higher education remains insufficient. A quantitative methodology was used, utilising a comprehensive questionnaire designed to gather data on educators' demographics, levels of BIM awareness, and the barriers to BIM implementation. The findings reveal that 50% of educators possess only moderate BIM skills, with a considerable number lacking adequate qualifications in the field. The study underscores the necessity for continuous curriculum development, improvement of the existing BIM education framework, and the removal of barriers impeding effective BIM education. The proposed strategies include enhancing educators' BIM knowledge, ensuring access to up-to-date software, and integrating practical workshops into the curriculum. In conclusion, by recognising

the varying levels of BIM awareness and addressing the identified challenges, this study paves the way for substantial improvements in the quality and relevance of BIM education within Malaysian TVET institutions, specifically Polytechnics Malaysia, aligning it with the demands of the rapidly evolving technological landscape in Malaysia.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This study titled Improving Building Information Modelling (BIM) in Technical Vocational Education and Training (TVET) in Malaysia Polytechnics commences with a comprehensive exploration of BIM implementation in Malaysian TVET education. Its significant aim is to recommend strategies for the effectiveness of BIM education in these institutions. Primarily, this study investigates the viewpoints of BIM educators, aiming to identify the levels of awareness in the implementation of BIM. It also determines barriers to implementing BIM faced by educators and recommends strategies to improve BIM implementation.

Moreover, the construction industry is experiencing a massive digital shift in BIM technology. This technological evolution is reshaping the global industry and holds the potential for transforming educational domains, specifically in TVET, globally, and in Malaysia. The construction industry plays a critical position in Malaysia's economic development, and integrating BIM into technical education programmes is perceived as essential to synchronise with the needs of the industry. Consequently, this assesses BIM's implementation in Malaysian TVET as a massive step towards cultivating future professional skills.

Additionally, this study is in the context of the Polytechnic Transformation Framework 2023-2030, announced by the Ministry of Higher Education Malaysia (MOHE, 2023). This framework underscores polytechnics' critical role in TVET education, with a selected consciousness on allowing educators to impart BIM knowledge and skills to diploma students throughout Malaysian Polytechnics. The study comprehensively examines international and Malaysian-specific literature on BIM inside the construction industry and its implementation in educational institutions. Furthermore, the study's conceptual framework is formulated by adapting existing theoretical models.

In terms of methodology, this thesis employs quantitative research methods to validate BIM implementation in Malaysian TVET institutions. A systematic sampling approach is used to enhance the reliability and validity of the results. The study adopts a deductive analytical method for objective evaluation, and questionnaires are designed to collect standardised statistical data for analysis. In addition, the analysis of this data led to a discussion of findings, culminating in conclusive recommendations.

Given the rapid advancement of BIM technology and its growing prominence in the construction industry, this study is up-to-date in ensuring that scholars' knowledge remains current and relevant. This research is valuable for government, educators, and industry stakeholders keen on effectively implementing BIM by evaluating and providing insights into the understanding of BIM implementation.

1.2 Research Background

BIM has emerged as a variable and has moved up for use (Sepasgozar et al., 2023). BIM is complicated with modelling competencies and associated strategies that facilitate the development, communication, and evaluation of digital technology at some unspecified time in the lifecycle technologies (CIDB, 2016). Eastman (2018) defined BIM as a reliable modelling technology and related techniques designed to create and study virtual records and data inside the project lifecycle. The BIM Guide First Edition, published through CIDB in 2016, allows data, integration, and identity across industries. Implementing BIM has enabled the Architecture, Engineering, and Construction (AEC) sector to work independently without being associated with stakeholders' viewpoints or collectively in or within the project (Bughio et al., 2021). BIM is critical for digitally integrating data generation, encouraging collaboration and directives, and assisting duties to be completed perfectly (Yahya Al-Ashmori et al., 2019). The effectiveness of BIM technology in growing productiveness and overall performance in the industry is extensively stated, as evidenced by a successful implementation in the UK, USA, Hong Kong, and Singapore (CIDB, 2016). In Malaysia, the implementation of BIM through the Public Works Department (PWD) in 2007 turned into a critical step in decreasing the vulnerabilities of the improvement industry (Saad & Haron, 2017).

BIM has emerged as one of the 12 key technologies blanketed within the Strategic Plan 2021-2025 to assist in aligning industries practices with the necessities of the Fourth Industry Revolution (IR4.0) (CIDB, 2020). There has been a significant increase in the number of governments enforcing BIM in 2018, and BIM implementation became obligatory for initiatives costing RM100 million or greater. Notable initiatives, together with the National Cancer Centre in Putrajaya and the Government Health Centre in Pahang, have been highlighted as pilot obligations. PWD may additionally want to provide valuable insights into or increase BIM implementation programmes in Malaysia. These initiatives have been similarly endorsed using PWD Malaysia's promotional strategies for BIM training tools and guidance programmes (Sinoh et al., 2020a). The fulfilment of BIM in Malaysia may be measured via its award-winning Klang Valley Mass Rapid Transit System Project in 2017 (Sinoh et al., 2020). Through the 12th Malaysia Plan (RMK12), which aims for 50% of projects worth more than RM10 million beneath production to implement BIM, this technique developed by PWD Malaysia is implemented (Munianday et al., 2023).

The increase in the implementation of BIM in Malaysia demonstrates its dedication to its implementation in the construction industry. The Malaysian

Construction Industry Development Board (CIDB) 2013 connected the Malaysian BIM Steering Committee to promote BIM. Working with nearby local construction industries, the committee turned to boosting the implementation of BIM across Malaysia by developing a comprehensive BIM roadmap for Malaysia in 2020. The BIM Roadmap Subcommittee treated governments, stakeholders, educational institutions, establishments, and educators gathered teams' expertise. A cautious approach to growing an accurate and relevant BIM roadmap becomes crucial (Harris et al., 2020).

The Malaysian BIM requirements have been crucial for the standardisation of BIM systems, the minimal submission technique for BIM models, and the harmonisation of laws and requirements with worldwide opposite numbers, which include Hong Kong, Singapore, and Australia. It also consists of institutionalising BIM technology to increase productivity, performance, and collaboration in Malaysia, enhancing productivity. Their improvement consequently displays a prime transformation in Malaysia that advanced productiveness, efficiency, and internal conversation.

Modern technology within the construction industry has seen increasing attention on technological improvements via those running inside AEC sectors, which is vital to its future increase (Rafsanjani & Nabizadeh, 2021). BIM has emerged as a revolutionary force within this new landscape of transformation of Computer Aided-Design (CAD) structures in architectural domains to sign an age of virtual talent in design, production, and industry strategies (Daniotti et al., 2020). BIM technologies' massive deployment within the AEC is evidence of their capacity to help managers optimise barrier effects whilst enhancing coordination and directive among production teams (Rafsanjani & Nabizadeh, 2021; Valinejadshoubi et al., 2022).

BIM is a helpful task management solution within the AEC industries, accommodating tasks including the amount classifications, specifications, standardised techniques of measurement, and cost estimates for every design element (Zhan et al., 2022). Due to its various benefits, professional bodies such as the Royal Institution of Chartered Surveyors (RICS), Royal Institutions of Surveyors Malaysia (RISM), and Board of Quantity Surveyors of Malaysia (BQSM) are endorsing and inspiring Quantity Surveyors (QSs) to implement BIM into their practices. Their reputation is that BIM can streamline construction processes (Ying & Kamal, 2021).

The barriers to BIM implementation and integration of BIM technologies are becoming essential solutions to common construction industry issues such as delays, conflicts over documentation, and costs incurred from construction projects. Chen (2022) highlighted that BIM is essential in construction industries by increasing value formulation while adhering to established standards. According to the 2019 Malaysian BIM Report, BIM, with the help of industries, highlights the need for Malaysia to devise techniques to further its deployment through CITP 2016-2020 (CIDB, 2020). The Construction Industries Transformation Programme (CITP) revealed an excellent surge in Malaysian Construction Industries' implementation of BIM, increasing from 17% in 2016 to 49% in 2019 and further rising to 55% in 2021(CIDB, 2021). This also demonstrates its capacity to cope with construction-related obstacles and increase competitiveness in the sector.

BIM is an innovative technology and application that has fully impacted the AEC industries. It involves the arrival and adoption of virtual representations of physical and sensible education to facilitate industries or different challenge selections, particularly as BIM is vital for training in TVET (Hoai Le et al., 2022a). It gives an interactive platform for TVET students to interact in actual-world situations, growing their knowledge and abilities. However, in the context of Malaysian TVET institutions, the implementation of BIM offers many disturbing conditions and problems. Despite this capacity, there may be problems with BIM's terrific and strong implementation of the establishments (Talent Corporation Malaysia Berhad, 2020). Contributing factors include a loss of suitable training and sources for curriculum improvement and resistance to adapting traditional teaching techniques to more technologically superior strategies. These problems spotlight the call for an approach to a systematic implementation of BIM in the educational system to ensure that students are hands-on-oriented and embedded with technological abilities.

Despite this potential, BIM is not fully implemented in those organisations. Contributing factors include the loss of appropriate education and resources, the need for curriculum reform, and resistance to adapting traditional teaching methods to more advanced methods. These problems build demand, and it involves planning the implementation of BIM in educational settings to ensure that students are hands-on and engaged with an emphasis on technical skills, as Malaysia's position on BIM (Talent Corporation Malaysia Berhad, 2020). Overcoming these constraints requires policy changes. However, conceptual change is also required to incorporate virtual development into AEC education effectively.

1.3 Problem Statement

BIM is a tremendous technological advancement within the construction industry. It demands deep understanding and skill for practitioners and educators. Despite Malaysia's great development in implementing and accepting BIM technology, a study by Yilei Huang (2018) suggests an excellent lack of professional talents required for its application. To effectively implement BIM implementation, collaboration among industry players and educational institutions, including universities and other institutions, is crucial (Sacks et al., 2013).

However, the implementation of BIM into the education system is described by the complexity and need for specialised education (Rodríguez-Rodríguez et al., 2016). Hadzaman (2015) and Hedayati (2015) highlighted that the implementation of BIM in Malaysia is in its beginning stage and needs support from industry and education for extensive implementation. The barriers, such as software programme compatibility and inadequate instructional materials identified by Puolitaival and Forsythe (2016), prevent the successful implementation of BIM in educational curricula. Saad and Haron (2017) mentioned that these barriers contribute to the implementation. Malaysian Higher Education Institutions (HEIs) need BIM courses in their curricula to prepare students to face industry challenges and satisfy technological necessities.

Despite this, Chen (2020) and Maharika (2020) argued that BIM adoption models focus on industries rather than education institutions, leaving an opening in curriculum integration and conceptual understanding. Similar to the findings from Dan (2023), the implementation of BIM in education institutions has received growing attention from diverse stakeholders, encompassing governments, industries, and academia. Many universities incorporate BIM into their curriculum across various methods and pedagogies. However, there may be a standard method for teaching BIM in the Diploma in AEC programmes within TVET institutions, specifically Malaysian Polytechnics.

Malaysian TVET institutions play an essential function in developing process-prepared students with suitable knowledge and skills (Subri et al., 2022; Yunos et al., 2019). Aiming to equip the national industry with productivity and specialise in areas that include engineering and technology, the TVET curriculum has been prioritised with the help of the Malaysian government for growth (Talent Corporation Malaysia Berhad, 2020). However, implementing this vision is hindered by a lack of knowledge and skills among TVET educators, which presents barriers to implementing BIM.

This study examines the barriers to BIM education and recommends effective strategies for its implementation in Malaysian TVET institutions including Malaysian Polytechnics. In the Malaysian Polytechnic Curricula, students are introduced to BIM across various subjects within the curriculum (Azhar & Fadzil, 2021) . Initially, students are introduced to BIM through the CADD subject, where they learn about computer-aided design software such as AutoCAD and Revit. As they progress to the next semester, this foundational knowledge is expanded in the Working Drawing subject, where students must apply their BIM skills and technical knowledge in creating construction drawings.

Affecting these boundaries is essential for educational consequences and services to satisfy the needs and growth of the industries. In addition, Tanko and Mbugua (2021) identified the gaps in BIM education, construction education, e-learning, curriculum, and information management, highlighting the need for further research in these areas. The study also discovered that the major global players in BIM education research are the United States, Australia, the United Kingdom, China, and Malaysia. In BIM Level 1, students tend to develop primarily 3D models, which means they need to continue to have BIM training and software acquired in higher education courses.

Technological changes in the construction industry have created the need to adapt curricula to industry needs. Since July 2016, the adoption of REVIT software has become increasingly crucial for BIM documentation. Mastery of REVIT software skills and understanding of BIM Level 1 provides students with exciting career prospects.

Hence, community colleges and polytechnics in Malaysia have responded by providing REVIT software usage skills to meet the demands of new markets in the construction industry, involving stakeholders such as contractors, developers, and consultants (Xin et al., 2020).

Numerous studies in Malaysia have focused on the readiness of the construction industry and higher education for implementing BIM, the perceptions of AECs in implementing BIM, and the barriers to BIM implementation in practice. However, research on BIM education in the Malaysian HEI system is limited (Zuraida et al., 2019). The current level of BIM education in the AEC curriculum is mainly at the 'infused level' where the BIM knowledge and skills are restricted in terms of collaboration and applying BIM knowledge and skills practically, with 62.5% of HEIs falling into this category and 37.5% at the 'awareness level' (Xin et al., 2020).

Consequently, this study seeks to discover the level of educators' awareness and the current barriers and gaps in BIM education. It also recommends effective and actionable strategies for its successful implementation in Malaysian Polytechnics as the announcement in the Polytechnic Transformation Framework 2023-2030 by the Ministry of Higher Education (MOHE) positions polytechnics as pivotal players in TVET education (MOHE, 2023). By addressing such barriers unexpectedly, this study desires to contribute significantly to Malaysia's national agenda by improving highly skilled professionals through TVET institutions capable of increasing industrial productivity. This is while closing any existing gaps between educational outcomes and industry requirements.

1.4 Research Questions

This research study aims to answer the following research questions:

1. What is the educators' awareness level of implementing Building Information Modelling (BIM) in Malaysian Technical Vocational Education and Training (TVET) Institutions at Polytechnics Malaysia?
2. What are the barriers to educators implementing Building Information Modelling (BIM) in Malaysian Technical Vocational Education and Training (TVET) Institutions at Malaysian Polytechnics?
3. What are the effective strategies for mitigating the identified barriers to the implementation of Building Information Modelling (BIM) in Malaysian Technical Vocational Education and Training (TVET) Institutions at Malaysian Polytechnics?

1.5 Research Aims and Objectives

This research aims to recommend strategies for improving BIM education in TVET institutions in Malaysian Polytechnics**.** Further are the lists of research objectives for this research study:

1. To identify the educators' awareness level of implementing BIM In Technical Vocational Education and Training (TVET) at Malaysian Polytechnics.
2. To determine the barriers for educators to implementing BIM In Technical Vocational Education and Training (TVET) at Malaysian Polytechnics.
3. To recommend strategies for improving BIM education in TVET Institutions, specifically at Malaysian Polytechnics.

1.6 Scope of the Research

The scope of this study focuses on the implementation of BIM in Malaysian TVET Institutions, specifically in Malaysian Polytechnics. The announcement in the Polytechnic Transformation Framework 2023-2030 by the Ministry of Higher Education (MOHE) positions polytechnics as pivotal players in TVET education (MOHE, 2023). A targeted approach was adopted for this study, where the respondents were BIM educators specialising in AEC teaching at Malaysian Polytechnics. These educators contribute BIM knowledge and skills to diploma students intensively in various polytechnics throughout Malaysia. Their involvement in teaching and effectively using BIM tools provides valuable insights into the current state of BIM education.

The study highlights four (4) major diploma programmes in Malaysian Polytechnics that implement BIM in their curricula, each representing a crucial aspect of BIM implementation in the industry.

1. Diploma in Architecture
2. Diploma in Civil Engineering
3. Diploma in Building Services/Facility Management.
4. Diploma in Quantity Surveying

1.7 Significant of the Research

The significance of this study is multifaceted and has several crucial implications. Firstly, it is a critical step in consolidating facts derived from research and conclusions drawn from study findings. This summary enables the foundation for future study efforts, as it offers complete and updated expertise on the awareness level of BIM implementations in TVET institutions in Malaysia, specifically in Polytechnics Malaysia.

Secondly, the findings have huge implications for numerous stakeholders, including educational institutions, educators, government, and industry players. These findings can be utilised as valuable guidelines for imposing, refining, and adapting academic curricula effectively to the evolving requirements of the economic region. Institutions and educators need more precise information on appropriate curriculum layout strategies to enhance the successful implementation of BIM.

Additionally, this study allows us to bridge the gap between curriculum and industry needs. It facilitates educational institutions to prepare graduates of TVET institutions to satisfy the expectancies and demanding situations of IR4.0. By equipping graduates with the necessary BIM-related talents and expertise, they can enter the workforce and be highly prepared to make meaningful contributions to technological developments and the production and engineering industries sector. Specifically, this plays an essential function in facilitating the adaptation of the TVET curriculum to the needs of the industry, equipping graduates with the assets to succeed in the IR4.0 era. This also sets the degree for future research efforts in this critical region.

1.8 Thesis Organisation

This study is meticulously organised into 6 (six) significant chapters, with every section with a key factor of this study. Chapter 1, the Introduction, provides a great review of the study. This part consists of information about its background, research problems, research questions, aims, objectives, scope, and significance, giving readers a complete view of its foundational elements.

Chapter 2, Literature Review, explores BIM theories and literature in intensity. It specialises in BIM implementation and awareness levels among educators while exploring barriers associated with its application throughout construction sectors and mitigating them, concluding with a reachable clarification of its research framework.

Chapter 3, Research Methodology, presents an in-depth account of the methodologies and approaches utilised throughout this study, outlining research design, research philosophy, information collection methods, sampling strategies, research approach, information evaluation, ethical attention, and hassle. Thus, it illuminates its underpinning processes and strategies.

Chapter 4, Results and Data Analysis, presents the detailed analysis and results of the data collected. This study recommended strategies to improve BIM in TVET Institutions in Malaysia, specifically in Malaysian Polytechnics. To achieve this, the Statistical Social Science Software Package (SPSS) version 27.0 advanced data analysis capabilities were employed. This tool helped facilitate in-depth analysis of the data.

Chapter 5 presents the Discussion of the results carefully interpreted against research objectives and questions, as well as a literature review posted at the outset of this study. It commences with a detailed description of the research questions, delving into how the findings relate to, extend, or enhance their foundational elements. This critical and reflective chapter examines the facts with consistent research questions.

Finally, Chapter 6, Conclusion and Recommendation, summarises the principal findings of the study, as well as proposes recommendations, discusses implications and limitations, and provides suggestions for future studies within this field.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The implementation of Building Information Modelling (BIM) in Malaysian Technical Vocational Education and Training (TVET) Institutions, specifically in Malaysian Polytechnics, is a critical point of this literature review. This section explores of BIM's role in the global construction industry, with a particular emphasis on its application within Malaysia, including the comprehensive MyBIM initiative. A key aspect of this chapter involves an in-depth examination of BIM implementation among educators in TVET institutions and its practical application in the Malaysian educational system, specifically in Malaysian Polytechnics. The chapter delves into the collaboration between BIM, architects, engineers, and construction professionals (AEC), assessing the implementation of BIM in TVET educational frameworks.

Further, the evolution and implementation of BIM are divided, highlighting the technologies and tools that help its adoption. It is identifying the awareness level of BIM implementation among BIM educators and addresses the barriers encountered in implementing BIM within the AEC from a Malaysian educational perspective. To counter these challenges, the section recommends various strategies to enhance BIM teaching within TVET institutions, aiming to mitigate these identified barriers and improve BIM literacy.

Concluding this chapter is an introduction to a conceptual framework grounded in the theoretical aspects of BIM education. This is a foundation for a more detailed discussion on BIM within Malaysian TVET institutions specifically in Malaysian Polytechnics.

2.2 BIM Overview

Building Information Modelling (BIM) is a revolutionary technology that has significantly impacted the construction industry. It is defined by the CIDB BIM Steering Committee as a process that encompasses modelling technology and related activities for generating, sharing, and applying digital information models from the beginning to the end of a project (CIDB, 2016). This technology is pivotal in promoting information exchange, enhancing integration, and aiding in conflict detection within the construction sector. Saad and Haron (2017) view BIM as more than a software tool; it is also integral for planning, design, monitoring, and management of construction projects. Similarly, Li and Yang (2017) highlight its role in facilitating intelligent services in 3D, further BIM's status as a sustainable technology in modern engineering projects.

The broader implications of BIM are its digitalisation to become a key technological driver in construction (Sepasgozar et al., 2023). The integration of Building Information Modelling (BIM) with the Internet of Things (IoT) is a significant advancement., enhancing the ability of Architectural, Engineering, and Construction (AEC) firms to meet industry demands (Rafsanjani et al., 2021). BIM's capacity to collaborate and communicate among various stakeholders is one of its most valued aspects (Srikanth et al., 2023). This technology has to address the industry challenges by organising building-related information efficiently and collaborative work (CIDB Malaysia, 2019).

In information technology, BIM has been a game-changer, notably expediting the construction industry's transition to digitalisation (Schiavi et al., 2022). Representing both the physical and functional attributes of construction projects, BIM is instrumental in enhancing planning, design, and overall lifecycle management. Its benefits are diverse, including but not limited to enhanced collaboration, increased productivity, and more sophisticated design processes (Eastman et al., 2018). This technology contrasts with traditional construction methods, such as 2D CAD, which often result in minimal collaborative project delivery (Bughio et al., 2021). BIM has bridged these gaps, innovated, and improved communication and management processes within the construction industry.

The emergence of BIM in the industry has also played a critical role in addressing environmental and sustainability concerns. Recent research by Kineber (2023) highlights BIM's potential in evaluating the environmental impact of construction materials and strategies, thereby aiding informed decision-making for sustainable development. This is in line with the broader goals of green building practices and sustainable architecture. Furthermore, the integration of BIM systems with artificial intelligence (AI) and machine learning, as highlighted by Růžička (2022), has opened up new possibilities for automated data analysis, predictive modelling, and optimisation of construction processes. This combination of BIM and AI is set to revolutionise project design and execution, promising a more efficient and cost-effective future for the construction industry (Růžička et al., 2022).

Lastly, BIM's transformative impact extends well beyond conventional construction practices, situating it as a key component of the industry 4.0 Revolution. It demonstrates its crucial role not just within the construction industry but also in the wider scope of industrial applications (Doan et al., 2019). The continuous evolution of BIM and its growing importance in addressing challenges in the construction industry. Table 2.1 shows the BIM implementation and characteristics based on the region.

Table 2.1 BIM Implementation and Characteristics Based on The Region

Region/Continent	BIM Adoption Brief Characteristic
North America	In the US, BIM has been mandatory since 2008 – the clear leader in BIM adoption. Canada has been running a BIM adoption program since 2014 to date. North America was clearly ranked as the most advanced continent in each approach.
South and Central America	Several countries are planning to introduce mandatory BIM in government projects in 2020-2022.
Europe	Open BIM standards and mandates in several countries (notably Scandinavian countries and the UK), many countries are preparing to introduce BIM standards or make BIM mandatory in public procurement.
Asia	Korea and Hong Kong are becoming leaders in the region, China and Japan have great government support in implementing BIM standards. However, the level of adoption on the continent must be rated as low despite these four strong leaders.
The Middle East	Unlike many countries in the Far East, the adoption of BIM in the Middle East is low. Individual projects are implemented, but there are no specific actions for the adoption of BIM in individual countries of the Middle East.
Africa	The South African government's growth targets for the use of technology in South Africa would benefit BIM stakeholders. However, the drive to adopt BIM on the continent is lacking. Only Architecture, Engineering and Construction (AEC) representatives recommended the adoption of BIM techniques in Egypt, starting with gaining full awareness of the BIM
Australia and Oceania	Mandate introduced in Australia, in New Zealand there is government support and significant promotion of BIM.

(Source: Zima et al., 2020)

2.2.1 Global Acknowledgment of BIM in Industry Professionals

The recognition of Building Information Modelling (BIM) in the Architecture, Engineering, and Construction (AEC) sector plays a critical role and has been notably varied across different regions and countries. Despite the acknowledgement of BIM's transformative effects in the built environment by industry professionals, there is a general lack of awareness among practitioners about the necessity of their BIM knowledge and skills in anticipation of its application. BIM has become a standard practice in several developed nations, such as the USA, Canada, the UK, Australia, New Zealand, Japan, Korea, and China. Most construction firms have integrated BIM technologies as part of the technological evolution within their industry sectors (Evangelista, 2021). According to Li and Yang (2017) studies in China, BIM has made a significant contribution to the construction sector through specialised software and tools designed for its application, leading to a growing recognition of its importance among industries.

Contrastingly, in certain developed Asian nations, as indicated by Ismail (2017) and Doan (2019), the scenario differs. Fitriani (2021) investigation in Indonesia revealed that while BIM awareness has started spreading in some countries, a considerable number of construction practitioners are still unaware of BIM's existence or its technological aspects. Moreover, it was found that in the Indonesian AEC industry, the limited knowledge and expertise in BIM hinder its widespread adoption due to a shortage of BIM professionals and specialists. In Brunei, for instance, BIM awareness stands at 60%, but only 40% of the industry feels the need for professional training in BIM implementation (Rahman, 2017).

In several developing countries, government incentives for BIM adoption and industry-led initiatives for enhancing awareness and skill development in BIM have been observed. However, it is clear that the awareness and proficiency of professionals in BIM are critical for its successful integration. The Construction Industry Development Board (CIDB, 2020) noted an increase in BIM usage by quantity surveying consultancies, with about 46.58% incorporating BIM in cost estimation and another 49.32% being aware of professional bodies like the Royal Institute of Chartered Surveyors (RICS) may be contributing to the lack of implementation of BIM in Malaysia (CIDB, 2020).

BIM continues to expand its influence across the global construction and architectural industries, with educational institutions and industry professionals increasingly integrating BIM into their workflows. Recent developments illustrate a growing emphasis on enhancing BIM competencies among students and professionals alike, ensuring that future architects and engineers are well-equipped to meet industry demands. For instance, BIM is being leveraged in educational programmes through competitions that are designed to engage architecture, engineering, and construction students. These initiatives not only foster a deeper understanding of BIM tools but also drive behavioural motivation among participants, thereby preparing them for real-world challenges (Ao et al., 2024).

Moreover, there is a noticeable effort to bridge the gap between educational outcomes and industry expectations, particularly in regions like Australia. The alignment of academic curricula with industry requirements is seen as crucial for producing graduates who are not only skilled in BIM but are also ready to meet the practical demands of the workforce (Abu Alieh et al., 2024). This focus on industryaligned education is accompanied by innovative pedagogical approaches, such as problem-based learning and network analysis, which have been shown to significantly improve the BIM competencies of students in built environment disciplines (Obi et al., 2024). These efforts underscore the importance of continuous learning and adaptation in the rapidly evolving field of digital construction.

In addition to educational advancements, BIM adoption is also gaining traction in developing countries, where it is being implemented to address specific challenges in the construction industry. For example, in Ethiopia, BIM is being used to overcome hurdles related to construction management and project execution. This implementation not only addresses existing challenges but also sets a foundation for future growth and development in the construction sector (Wasse & Dai, 2024). Similarly, in New Zealand, the development of BIM frameworks is helping to establish a standardised approach to BIM adoption, ensuring that the benefits of digital modelling are realised across the entire construction process (Dang et al., 2024). These examples highlight the global spread of BIM and its critical role in shaping the future of construction and architectural practices worldwide.

In short, the awareness of BIM among AEC professionals varies across regions and countries. While many developed countries have broadly implemented BIM, developing countries continue to face challenges due to a lack of BIM technology expertise, underscoring the importance of awareness campaigns and educational initiatives (CIDB, 2020). The journey to broaden BIM awareness is ongoing, encompassing not just the recognition of BIM but also the understanding of its multifaceted benefits and implications for the AEC industry. As the sector evolves, it is crucial for professionals to stay of advancements in BIM technology and practices. Fully understanding the potential of BIM and its transformative role in the construction industry is crucial to maintaining competitiveness and innovation in the contemporary AEC field (CIDB, 2020).

Moreover, educational institutions and industry associations make significant contributions to promoting BIM awareness. Their collaboration in implementing BIM-related courses and training into educational programs prepares future professionals and boosts demand among current practitioners (CIDB, 2020). BIM competency goes beyond just software adoption; it encompasses broader aspects like enhancing project coordination, reducing errors, and improving decision-making. The AEC sector is poised to fully exploit BIM's potential in the future. Although there has been a significant increase in BIM awareness in certain sectors, a worldwide effort is required to bridge the knowledge gap and develop a deeper understanding of BIM capabilities. Initiatives taken by governments, industry groups, and educational institutions play a crucial role in implementing BIM in all AEC projects and ensuring active participation from the workforce.

2.2.2 BIM in Malaysia: A Comprehensive Overview

In the Malaysian construction sector, the implementing and challenges of Building Information Modelling (BIM) are continually evolving. Research by Yahya Al-Ashmori (2019) reveals concerning data indicating that BIM usage in Malaysia's construction activities is below 4%, a clear sign of the limited application of BIM methodologies in this sector. Additionally, it is noted that numerous entities within this industry face challenges due to general unfamiliarity with BIM technologies at various project stages (Yahya Al-Ashmori et al., 2019).

Addressing these barriers, the Construction Industry Development Board (CIDB) of Malaysia has launched various initiatives, such as the Construction Industry Transformation Plan (CITP) 2016. Subsequently, there has been a noticeable enhancement in BIM knowledge and operational efficiency, as evidenced by the increasing BIM awareness rate (CIDB Malaysia, 2019a). Different levels of organisational proficiency in understanding this emerging technology are apparent. In 2017, a training centre was established with a RM2.5 million investment, aiming to offer extensive training to diverse stakeholders like industry professionals, educational staff, and students (Sinoh et al., 2020).

The role of governmental policies in advancing BIM within Malaysia's construction industry has been significant. The government has been proactive in promoting BIM awareness and providing assistance to companies for BIM implementation (Sinoh et al., 2020). The Malaysia BIM Report 2019 shows that 46.58% of industry players use BIM, while 49.32% are aware but not yet using it for cost calculations. There is an evident drive to enhance BIM implementation, particularly by involving architectural consultants who demonstrate extensive knowledge (CIDB, 2020).

However, Shehzad (2022) revealed that as of 2020, only 13% of both government and private sectors implemented BIM in their operations, underscoring the ongoing obstacles in BIM in Malaysia. Additionally, research by Kamaruzzaman (2023), observed an adoption rate of BIM, with limited organisations employing it in their planning and design processes. Recent findings Omar and Fateh (2023) showed that a majority of project participants had a solid understanding of BIM tools, yet some lacked this knowledge, emphasising the need for ongoing BIM education and awareness enhancement in the industry.

Interestingly, Munianday (2023) presented a contrasting view, the necessity for BIM implementation in actual construction projects to augment the current low BIM usage in Malaysia. This underscores the importance of practical applications in reinforcing design expertise and the focus on BIM utilisation. Despite the BIM awareness and education in the Malaysian construction field, the path ahead is still fraught with challenges. BIM implementation is gradually becoming more prevalent in the national construction landscape, and the collaborative efforts of government bodies, industry stakeholders, and educational institutions are crucial in narrowing the BIM technology skill gap and ensuring effective implementation, ultimately contributing positively to the advancement and growth of Malaysia's construction industry.

2.2.3 The Emergence of MyBIM

The implementation of the Malaysian Building Information Model (MyBIM) initiative has been initiated, under the stewardship of the Construction Industry Development Board (CIDB). The CIDB's role in this context is to support the adoption of BIM throughout Malaysia (CIDB, 2016). MyBIM is an integral part of the digital transformation journey in the construction industry, aiming to refine BIM methodologies and practices. The MyBIM Institute serves as a central repository and learning centre for enhancing BIM proficiency and expertise among industry professionals, academicians, and students (MyBIM Central, 2024). The initiative emphasises improving digital efficiency across the board through both educational programs and evaluative measures.

The mission of MyBIM is to digitally empower the construction sector. It aims to generate new employment opportunities, augment firm capabilities, and boost job growth and competitiveness (CIDB Malaysia, 2019a). Collaborating with a diverse range of partners, including government entities, industry participants, and academic circles, the MyBIM Centre (2024) seeks to cultivate a conducive environment for successful BIM implementation and adoption. MyBIM offers a variety of structured frameworks, educational modules, and materials tailored for professionals and industries to implement BIM into their operational and educational frameworks. These initiatives encompass BIM-focused educational courses, certification programs, research support, as well as the development of BIM standards and guidelines (CIDB, 2021). The overarching goal is to equip personnel with BIM proficiency and to promote best practices in construction.

The CIDB's MyBIM established by the Construction Industry Development Board of Malaysia, lays out a clear and detailed roadmap for BIM implementation in Malaysia (CIDB, 2021). This plan outlines a systematic method for implementing BIM, highlighting crucial aspects such as design evolution, capacity enhancement, research, development, inter-industry collaboration, and understanding the strategic impact of these initiatives with various stakeholders. This initiative is an evidence to Malaysia's commitment to implementing BIM. However, challenges persist, as numerous industries struggle to embed BIM within their operational frameworks (Othman et al., 2021).

2.3 The BIM Awareness Level

A crucial aspect of Building Information Modelling's (BIM) 'awareness level' is how it correlates with its acceptance in the industry. This involves individuals or