Case study on barriers to building information modelling implementation in Malaysia

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Received 30 October 2021
Revised 2 March 2022
25 September 2022
Accepted 13 October 2022

Abstract

Purpose – There is a dearth of studies conducted by local academics on actual building information modelling (BIM) projects to analyse the actual hurdles of BIM adoption. The majority of BIM research focuses on the technology's general advantages, disadvantages, issues and limitations. In addition, research on actual BIM projects that have integrated BIM throughout the project is necessary to increase the current low number of BIM users in Malaysia. Consequently, the purpose of this study is to examine the challenges BIM adopters experience while implementing BIM in their projects and how they overcome them.

Design/methodology/approach – An in-depth interview session was used to collect data based on a case-study methodology. In Malaysia, three BIM projects were chosen, given the available resources. To evaluate the data in this qualitative study, NVivo was used.

Findings – According to the findings, the most important elements influencing the adoption of new technology and innovation were people and capital. The most significant impediments to BIM adoption are the appraisal of time and finances, as well as the tolerance of changes in approach.

Originality/value – Collaborative training and BIM education have been the most explored solutions for reducing BIM difficulties. As a result, these concerns and solutions should be investigated and implemented to ensure project success and fully use technological innovation.

Keywords Construction industry, Barriers, Malaysia, Case study, Challenges, Building information modelling (BIM)

Paper type Case study

1. Introduction

The construction sector is critical to a country's socio-economic progress. The construction industry accounts for 6% of the global gross domestic product (World Economic Forum, 2018). In addition, the architectural, engineering and construction (AEC) sector has been noted to be

Ministry of Higher Education Malaysia for Fundamental Research Grant Scheme with Project Code: FRGS/1/2019/TSSI11/USM/02/1.

Data availability statement: Some or all data, models or code generated or used during the study are proprietary or confidential in nature and may only be provided with restrictions (e.g. anonymized data).

Journal of Facilities Management
Vol. 21 No. 4, 2023
pp. 511-534
© Emerald Publishing Limited
1472-5967
DOI 10.1108/JFM-10-2021-0132

booming in emerging nations (Girginkaya Akdag and Maqsood, 2020). Owing to its complexity, the construction industry faces numerous issues, including low productivity, inadequate quality, price inflation, construction waste, delays and a lack of information sharing among project stakeholders (Azhar, 2011; Banawi, 2017; Ullah *et al.*, 2019). The growing digitization of the construction sector offers the opportunity to completely re-evaluate contemporary construction plans to address future concerns and alleviate the barriers raised. Building information modelling (BIM) has the potential to transform the construction industry, and it is consequently considered the sector's future (Qureshi *et al.*, 2020). BIM is a construction reality method that entails creating a digital model during the design stage, gradually developing it during the construction stage and using it throughout the operation and maintenance phases. It has the ability to improve construction sector performance by eliminating inefficiencies, enhancing efficiency and increasing collaboration among project team members (Abanda *et al.*, 2018; Olanrewaju *et al.*, 2020; Ullah *et al.*, 2019).

According to CIDB (2019), the adoption rate of BIM in the Malaysian construction sector in 2019 is 49%, but the adoption rate of BIM in developed nations is over 70%. These nations include the USA (79% in 2015), Australia (71% in 2015), the UK (73% in 2020), Denmark (78% in 2016) and Canada (86% in 2019) (Zhang *et al.*, 2019). Due to BIM mandates, BIM use in the USA, the UK and other European countries is expanding rapidly. In developing nations such as China, Singapore and Japan, there is a gradual increase in BIM usage. In China, BIM adoption reached 67% in 2014, according to Jin *et al.* (2015), whereas in Japan, BIM adoption increased from 27% in 2013 to 43% in 2015 (McGrawHill, 2014). Consequently, the Ministry of Works set a goal to adopt BIM by 50% next year and 80% by 2025 as part of the Public Works Department (PWD) Strategic Plan 2021–2025 (Afiq Aziz, 2020). After various fact-finding sessions, it was discovered that the number of studies undertaken by local academics on real BIM projects has been insufficient to identify the problems of BIM implementation, in addition to those identified from literature reviews and other BIM resources. The majority of BIM research has concentrated on the advantages, risks, barriers and limitations of BIM. To expand the number of BIM users in Malaysia, it is necessary to conduct research on existing BIM projects that have used BIM throughout the project. Future projects may use this BIM-based project as a model for effective BIM implementation. As a result, this study reviews genuine BIM projects that have met challenges and assesses how these challenges might be overcome so that BIM can be used in the future.

2. Literature review

This section discusses the findings of desk research on all areas of BIM barriers and how to address them in both international and Malaysian contexts.

2.1 Barriers of Building information modelling implementation

To examine the barriers to BIM adoption, Ayinla and Adamu (2018) identified six themes: cost, culture, expertise, technology and interoperability, client demand and legal issues. Lack of policy efforts and research domains constitute other impediments to BIM implementation in the Kingdom of Saudi Arabia, according to Al-Yami and Sanni-Anibire (2019). Lack of interest from customers and industry stakeholders, insufficient BIM team experience and lack of mentorship from a BIM champion are among the issues experienced by Saudi Arabian AEC firms, according to Almuntaser *et al.* (2018). Financial constraints, lack of BIM understanding, the poor introduction of BIM concepts, lack of awareness of BIM benefits and lack of governmental enforcement are among the most significant barriers to BIM adoption, according to Gamil and Rahman (2019). Poor BIM adoption in Malaysia is mostly due to a lack of expertise, exorbitant adoption costs, a scarcity of experienced people and an unwillingness to adapt working processes to BIM. In the industry, there is space for increased BIM usage and development (BIM Day, 2019). Several researchers have identified and investigated some of these concerns.

2.1.1 Interoperability. Interoperability, defined as the exchange of data between different software packages, is required at every stage of the smart building development process. Interoperability is essential for the smooth exchange of information between various BIM platforms (e.g. Revit®, Tekla, Inventor, IDAT Precast, CATIATM and Autodesk Fabrication), organisational systems and smart components (Li *et al.*, 2019). Well-developed software interoperability can cut the total cost of a project dramatically and accelerate the time to return on investment (Lilis and Kayal, 2018). However, establishing well-developed software interoperability comes with a considerable cost in terms of time and money spent on development (Costin and Eastman, 2019). Li *et al.* (2019) propose that information exchange may be improved using interoperability tools based on standard data patterns and Industry Foundation Classes (IFC). The main cause of poor BIM software interoperability is inconsistency in relevant BIM software standards, such as data interchange format and data model (Yang *et al.*, 2021). However, prior studies have limitations, and a vast majority of BIM applications still lack adequate interoperability. Even though interoperability has decreased during the past five years, interoperability problems still pose a considerable potential threat (Chan *et al.*, 2019; Tan *et al.*, 2019). Construction, design and lack of intelligence in data interpretation by diverse software, or their incapacity to read IFC data, posed serious interoperability challenges (Singh *et al.*, 2017). While small and medium enterprises BIM software support systems are broadly substandard, this is a deterrent factor (Vidalakis *et al.*, 2020). Interoperability can only be achieved by extending computer-aided design and planning information technology devices and applications, three-and four-dimensional visualisation and modelling of laser filtering programmes (Morrison, 2010).

2.1.2 Client's request. The most frequently identified obstacle in all types of professions is the lack of client demand (Almuntaser *et al.*, 2018; Ayinla and Adamu, 2018; Georgiadou, 2019; Van Tam *et al.*, 2021). The construction sector was unprepared to adopt BIM. The speculation surrounding the immediate benefits of BIM, particularly during the planning phase, has led to insufficient demand for BIM adoption. The lack of demand for BIM was also attributable to the belief that BIM could not reduce the amount of time spent on drafting as compared to the current drawing method (Sriyolja *et al.*, 2021). According to NBS (2017) data, 66% of clients are unaware of the benefits of BIM, thus, indicating a need for further client education. It is difficult to use BIM in the construction industry without a client request. This is comparable to the usage of BIM; if clients fail to demand it, experts and businesses will not see the value associated with its use (Damian, 2008; Olanrewaju *et al.*, 2020; Wong and Gray, 2019). Clients are acknowledged as critical actors, and public policy is identified as a common target for supporting innovation in the AEC industry (Jiang *et al.*, 2021). According to NBS (2017), client demands are more critical when a business implements Level 2 BIM, as it involves costing and scheduling features that are tailored specifically to the organisation. Numerous stakeholders are concerned about technological advancements. Clients are only willing to adapt if the benefits are proven, as they are concerned that embracing emerging innovations for a project will allow bidders to raise bid prices, reducing their pool of bidders. As a result, it is clear that increased client demand and governmental support have influenced the construction industry's adoption of BIM (Awwad *et al.*, 2020). Professionals have dropped the concept of obtaining BIM training and certification for this single reason (Marefat *et al.*, 2019).

2.1.3 Time and financial aspect. According to the results of a study that included respondents from the USA, Canada, the UK, Ghana, China, India, Australia and South Africa, the most common barriers to the adoption of BIM are the high-cost expense of investment and insufficient benefits in comparison to the cost, as well as an unwillingness to develop new technology (Hyarat and Hyarat, 2022). Financial restrictions constitute one of the primary impediments to BIM adoption (Gamil and Rahman, 2019; Hong *et al.*, 2020; Lee, 2019). To upgrade BIM, a business must periodically update its equipment to run the prepared programming. Malaysia's building industry now faces the challenge of implementing BIM with a major innovation component. As they attempt to conceal another workspace within their organisation, the organisation must account for the expenditures connected with training its representatives and even hiring additional specialists who have adequate BIM knowledge (Latiffi *et al.*, 2013). Apart from these short-term investments, a considerable barrier is the lack of long-term financial support for BIM implementation (Won *et al.*, 2013). At the operational level, substantial software and hardware expenditures, as well as costs connected with the education and training of personnel and the implementation of changed BIM processes, have been recognised as impediments (Du *et al.*, 2014).

Time constraints are also considered a barrier to BIM implementation and use, as accelerating the adoption of BIM frequently results in increased responsibilities for individuals, which can lead to time constraints and morale demonisation issues. While BIM is intended to provide long-term benefits, it may require an investment in learning new tools, software and work practices. Owing to the increased emphasis on project teams, project managers and the BIM department, these individuals may not always have the time or necessary support to fully use BIM. Time constraints are also associated with people's tenacity in implementing BIM when they believe it is not worthwhile. Time constraints may also be a result of people's typical duties inside their businesses. Implementing BIM may occasionally impose extra tasks on individuals (e.g. highly organised document management or design coordination) in addition to their current employment. Even if individuals are eager to take on these obligations considering their abilities, they may not always be able to do so owing to time constraints (Siebelink *et al.*, 2021). Previous research has validated stakeholders' concerns about wasting time and money on labour training as well as their tendency to underestimate or overestimate the time and resources they have committed to this type of training (Eadie *et al.*, 2013). Furthermore, stakeholders bear risks linked to a potential loss in worker productivity as a result of the learning curve. As a result, the expense and time required for training would slow the adoption of BIM (Tan *et al.*, 2019).

2.1.4 Adoption of changes in practice. BIM necessitates the transformation of contractual agreements from traditional to integrated procurement approaches (Sebastian and van Berlo, 2010). Constructors resisted changes due to the convenience of existing approaches. They believed that the benefits of BIM were false and intangible. Changing people's perceptions of BIM's use will necessitate a significant cultural shift (Sriyolja *et al.*, 2021). Furthermore, resistance to change may hinder effective collaboration among stakeholders. This term describes the point at which established knowledge, experiences and behaviours of individuals and organisations conflict during the adoption of BIM, which necessitates significant shifts in established mindsets and practices (Georgiadou, 2019). This is critical at all organisational levels, from top management all the way down to the shop floor level, where projects are completed. Inevitably, BIM implementation alters project delivery and, in some cases, the organisation's structure (Eastman *et al.*, 2011). Construction stakeholders are notorious for their resistance to change. They are used to paper-based methods and are hesitant to embrace new technology. Convincing these sceptics to accept BIM can be difficult (Arayici *et al.*, 2011; Damian, 2008; Panuwatwanich and Peansupap, 2013; Tan *et al.*, 2019). This category encompasses difficulties related to individuals and established cognitive practices. Contractual constraints inherent in traditional procurement procedures obstruct the effective implementation of a performance-based system, i.e. a system that incorporates whole-lifecycle assessment into project design and delivery. Organisations that can coordinate planning phases and use top-to-bottom construction learning will have the most prominent preferred point-of-view as BIM implementation speeds up the initial stage of data and information dispersion during the construction process (Zainon *et al.*, 2016). Numerous organisations have opted out of BIM because of the alterations that must be implemented before it can be deployed properly. BIM deployment requires changes to all aspects of an organisation's operations and business processes. Consequently, these individuals must proceed with caution as they decide what to change, why to change it and how to implement the changes in the organisation. People may lose faith in BIM if there is a risk of misconceptions and disillusionment as a result of rapid change. As a result, a proper fit between the capacity of people to change and the projected rate of change must be ensured (Siebelink *et al.*, 2021).

2.1.5 Teamwork and partnership. As new opportunities for project team participation have been created with the implementation of BIM, numerous concerns may develop. One of the most serious BIM barriers internationally is a lack of collaboration between stakeholders (Harding *et al.*, 2014; Lee, 2019). A broad collection of stakeholders, including the client, designer, engineer and contractor, cooperate on a single, integrated BIM model in the ideal situation for BIM implementation. However, the possibility of such integration remains constrained, and past research has revealed that stakeholders maintain negative attitudes towards collaborative projects (Khosrowshahi and Arayici, 2012). Collaboration among stakeholders is thus critical yet challenging in a BIM-based project (Tan *et al.*, 2019). Sebastian and van Berlo (2010) noted that when contract processes are not effectively coordinated and planned, BIM adoption becomes extremely challenging, as the entire contractual process is not constructed to accommodate new technology. Contractual coordination is a requirement for BIM adoption. Hence, if a project is not effectively coordinated and processes are not well specified, BIM cannot be accepted, as the BIM adoption must be integrated into the contract from the start (Olanrewaju *et al.*, 2020). In addition, construction firms can revise IFC benchmarks with the use of a model server to improve data transmission between BIM systems. As a result, cooperation is critical in uniting all stakeholders and is one of the most arduous obstacles to overcome when implementing BIM (Table 1).

Barriers	References
Interoperability	Li *et al.* (2019), Lilis and Kayal (2018), Costin and Eastman (2019), Costin and Eastman (2019), Yang *et al.* (2021), Chan *et al.* (2019), Tan *et al.* (2019), Singh *et al.* (2017), Vidalakis *et al.* (2020), Morrison (2010), Ku and Taiebat (2011), Ayinla and Adamu (2018), Raouf and Al-Ghamdi (2019), Aranda-Mena *et al.* (2009)
Client's request	Almuntaser *et al.* (2018), Ayinla and Adamu (2018), Georgiadou (2019), Van Tam *et al.* (2021), Sriyolja *et al.* (2021), NBS (2017), Damian (2008), Olanrewaju *et al.* (2020), Wong and Gray (2019), Jiang *et al.* (2021), NBS (2017), Awwad *et al.* (2020), Marefat *et al.* (2019), Zhou *et al.* (2019), Khosrowshahi and Arayici (2012)
Time and financial aspect	Hyarat and Hyarat (2022), Gamil and Rahman (2019), Hong *et al.* (2020), Lee (2019), Latiffi *et al.* (2013), Won *et al.* (2013), Du *et al.* (2014), Siebelink *et al.* (2021), Eadie *et al.* (2013), Tan *et al.* (2019), Zhou *et al.* (2019), Raouf and Al-Ghamdi (2019)
Adoption of change in practice	Sebastian and van Berlo (2010), Sriyolja *et al.* (2021), Georgiadou (2019), Eastman *et al.* (2011), Arayici (2011), Damian (2008), Panuwatwanich and Peansupap (2013), Tan *et al.* (2019), Zainon *et al.* (2016), Siebelink *et al.* (2021)
Teamwork and partnership	Harding *et al.* (2014), Lee (2019), Khosrowshahi and Arayici (2012), Tan *et al.* (2019), Sebastian and van Berlo (2010), Olanrewaju *et al.* (2020)

Table 1. Summary of perceived barriers to BIM implementation

2.2 Successful implementation strategy for Building information modelling

2.2.1 Government support. Government assistance is a significant enabler of BIM adoption (Husain *et al.*, 2018). Consequently, it is recommended that governments play a more active role in promoting BIM in the construction industry from multiple perspectives, including the identification of ways to use BIM throughout the project life cycle and the enactment of legislation to protect intellectual property and digital asset ownership. Simultaneously, businesses and government agencies may provide practitioners with additional learning opportunities to help them reduce BIM launch expenses (Wu *et al.*, 2021). The Malaysian government should recognise the benefits of BIM and continue to promote its use in private-sector projects. Subsidising BIM software expenses would enable the private sector to participate in the pilot stages of BIM. Additionally, it is during this phase that the notion that the project is impractical or difficult to complete is formed. The findings imply that the government should budget for BIM and create a BIM-based allocation cell to ensure that budget allocations are used appropriately (Manzoor *et al.*, 2021). The government and specialised organisations should devise a strategy to expedite its adoption. The plan should consider both initial investment, software and training expenditures, and BIM standards and guidelines (Hyarat and Hyarat, 2022; Sriyolja *et al.*, 2021). As the industry's greatest client in developing nations, the government is the key driver of BIM. Government intervention would result in the formulation of policies similar to those observed in developed countries. As a result of the strategy, the industry would be encouraged to embrace BIM, and the rising benefits of BIM adoption would result in increased government participation, as seen in the established construction industry (Saka *et al.*, 2019).

2.2.2 BIM education. BIM training and education are crucial for promoting BIM adoption in AEC organisations (Succar, 2012). According to both schools and professional organisations, BIM education is vital for enhancing BIM specialised learning and recruiting for the sector (Wu and Issa, 2013). Academics in the construction field are urged to embrace BIM as they have a significant impact on their students' BIM education. The curriculum for built environment courses in Malaysian tertiary institutions should be revised to include BIM education with the goal of developing a stream of BIM-oriented professionals (Olanrewaju *et al.*, 2020). The initial phase of BIM adoption is in tertiary and practitioner education, with Malaysian Higher Learning Institutions being encouraged to incorporate BIM lectures into their curricula so that graduates may comprehend and appreciate BIM technology in preparation for future professions (CREAM, 2014). The programme should be aimed towards students in the construction industry who are proficient in both BIM and multidisciplinary skills. Eventually, many countries have actively pursued BIM skill training courses based on core, specialised courses in colleges and universities that serve as the foundation for diverse architecture, engineering and construction majors (Wu *et al.*, 2021). Additionally, BIM should be integrated into the educational process (architecture college, engineering college) and specialised associations should provide training courses and seminars on BIM and other new technologies. Implementation of the BIM will be facilitated by university collaboration and the fostering of a research culture. The government is committed to expanding scholarship opportunities for students and instructors (Manzoor *et al.*, 2021). In contrast, AEC firms can collaborate with foreign firms that have already adopted BIM, which is a good first step towards BIM adoption in Malaysia (Hyarat and Hyarat, 2022).

2.2.3 Provision of legislation of Building information modelling usage. Legislation is the primary driver of industry shifts towards BIM, with obvious ramifications for those responsible for establishing regulatory requirements and voluntary standards (Georgiadou, 2019). Since 2009, it has been mandatory to boost all public sector projects to over RM100m by implementing BIM (Bernama, 2019). Similarly, it is believed that the government plays a vital role in fostering BIM adoption. For instance, Wong *et al.* (2010) examined the public and private sectors' contributions to successful BIM implementations in a variety of nations. They concluded that proactive government involvement is essential for achieving widespread BIM adoption. This could be attributable to the fact that government support promotes an atmosphere suitable for uniform and consistent legal jurisdictions, education and research and development (R&D) in BIM. Wong *et al.* (2010) undertook an assessment of the literature on BIM initiatives undertaken by the Hong Kong and US governments. They discovered that the government has a crucial influence on the BIM adoption of any country. In a handful of nations, such as Finland, Norway, Denmark and Singapore, the government can be a considerable economic force. In contrast, the government is more likely to intervene as a regulator enforcing BIM compliance in an open economy such as Hong Kong, where the private sector is a major contributor to and driver of the economy (Wong *et al.*, 2010). They concluded that the government's proactive engagement is critical for achieving a high percentage of BIM adoption. This may be because government support fosters a consistent and uniform legal, educational and R&D environment for BIM (Jiang *et al.*, 2021).

2.2.4 Collaborative development by training. Training is one of the most frequently recognised essential enablers for successful BIM deployment. Despite this, there is a dearth of theoretical and empirical research on best practices in BIM training, particularly on intervention design and delivery, from the perspective of various construction supply chain disciplines. A detailed training plan outlining anticipated training needs and resources should also be developed. In addition, competent, well-designed training and education courses contribute to the upskilling of personnel and the expansion of their understanding of BIM concepts and technology (Ahn *et al.*, 2016). The evaluation of training completion should include assessments of learning outcomes, behavioural responses and expectations of whether training programmes increased trainee values and the extent to which new knowledge and abilities resulted in improved work performance. Comprehensive training and education are essential for exceeding end-user expectations and building a long-term commitment to continual development (Abbasnejad *et al.*, 2021). Offering staff training is a critical component of organisational BIM adoption (Wan Mohammad *et al.*, 2018). Moreover, management must offer the appropriate software and technology for BIM deployment, as well as the competence to run them. This also indicates the firm's technical readiness to deploy BIM (Sinoh *et al.*, 2020).

2.2.5 Technology and provision of trial software. Memon (2014) claimed that providing trial software, training construction people and incorporating BIM into university courses are all viable approaches for enhancing BIM implementation and increasing its effectiveness. Consequently, exposure to software on a trial basis may serve as a stepping stone towards the wider adoption of BIM practices. As a method for introducing new users to products, software demos are gaining popularity. During this trial period, a great user experience is crucial because the objective is to convert as many trial users as possible into paying customers. Companies use free trials to promote potential customers for their products. This will allow the customer to try the product before deciding whether to purchase it, which will reduce any uncertainty a buyer might have about the product's functionality (Tolvanen, 2020). According to research conducted by Ahuja *et al.* (2020), permission to use trial software features on pilot projects was granted to 56% of the total number of respondents, with 46% of those who adopted BIM stating that they had been granted permission to do so. A similar number of "non-adopters" (42%) agreed on the significance of experimenting with software features before purchasing it, with an additional 43% percent believing that software should be available for a sufficient period of time to explore its potential benefits (Table 2).

3. Research methodology

This section describes the methodology used in this study and the techniques used to ensure the validity and reliability of the results.

3.1 Research approach and strategies

Qualitative research is undertaken when a group or population desires a comprehensive grasp of a topic or situation. Typically, qualitative data are more specific than quantitative data. Due to the technical and complicated nature of BIM, which necessitates a broad understanding, the challenges and solutions must be discussed with a specific set of BIM adopters. If clients gain knowledge from BIM adopters, they will be better equipped to compare BIM difficulties and solution concepts to a real-world BIM project. Therefore, this work focuses mostly on qualitative research.

Case studies are a research strategy that permits the application of qualitative research tools. A case study refers to the individuals, organisations or occurrences that are the focus of the study (Sturman, 1997). Case study research is an in-depth investigation of one or more case studies that includes qualitative data and conclusions gained from earlier literature reviews. The case study allows the researcher to determine and investigate as the research develops. Due to the requirement to comprehensively analyse various BIM projects, discover additional causes for the obstacles that develop in BIM projects and determine how the obstacles are overcome, this study will adopt a case study approach. The nature of the case study is explanatory. There will be an examination of the relationship between cause and effect, as well as definitions and explanations of why things occur. The limitations inherent to BIM projects are described in detail, as are the methods for overcoming them. As a result, it is reasonable for this study to adopt this methodology to provide an in-depth investigation of the actual problems encountered by BIM projects in Malaysia and how they are addressed in practice.

3.2 Selection of case studies

Case studies collect in-depth information about a particular business phenomenon, whether that phenomenon occurs in similar companies or surroundings or in a single unique case (person, organisation or setting). Researchers typically use two designs in case study

Implementation strategy for BIM	References
Government support	Husain *et al.* (2018), Wu *et al.* (2021), Manzoor *et al.* (2021), Hyarat and Hyarat (2022), Sriyolja *et al.* (2021), Saka *et al.* (2019)
BIM education	Succar (2012), Wu and Issa (2013), Olanrewaju *et al.* (2020), CREAM (2014), Wu *et al.* (2021), Manzoor *et al.* (2021), Hyarat and Hyarat (2022)
Provision of legislation of BIM usage	Georgiadou (2019), Bernama (2019), Wong *et al.* (2010), Jiang *et al.* (2021)
Collaborative development by training	Ahn *et al.* (2016), Abbasnejad *et al.* (2021), Sinoh *et al.* (2020), Wan Mohammad *et al.* (2018)
Technology and provision of trial software	Memon *et al.* (2014), Tolvanen (2020), Ahuja *et al.* (2020)

Table 2. Summary on successful implementation strategy for BIM

research (Korey, 2005). Nonetheless, the multiple-case study research method is used herein. Compared to a single case study approach, the conclusions and evidence of many case designs are more convincing, making this case study more trustworthy (Yin, 2013). In addition, because the multiple-case design is considered to be more engaging, it should be more robust in identifying the obvious challenges connected with BIM adoption and the solutions used to overcome them. The BIM project cases were chosen as the units of analysis for this study.

The case studies were selected from 61 BIM projects reported by PWD's BIM Division. The BIM project's criteria adhere to the Malaysian Construction Industry Development Board's (CIDB) guidelines (CIDB, 2015). Several criteria were considered when the case studies were selected. Table 3 depicts the BIM project criteria.

Owing to the lack of examples within the local industry, the initial decision was made to use government BIM projects as samples. However, several BIM projects for private organisations were subsequently acquired. The PWD BIM Division oversees 46 BIM projects, including nine completed construction projects under RMK9 and RMK10. This was revealed during a conversation with a senior civil engineer of the PWD. Thirty building projects and seven road projects have been authorised under RMK11. Additionally, under RMK12, a 50% target is planned to be met for projects worth more than RM10m. Two project types are available from this list: pilot projects and BIM projects. Malaysia had fewer than 15 BIM projects in addition to government projects (private projects), according to the PWD BIM Division. In total, 61 BIM projects in Malaysia meet the requirements stated below.

Initially, the researcher addressed official emails to all 61 BIM project organisations requesting consent to conduct the research. However, only three firms responded, and due to time constraints, only these three were included in the study. Margarete (1995) asserted that identifying the necessary sample size is dependent on the type of study, and in some instances, three to five case studies are adequate. Using semi-structured interviews, the researcher collected data from the three selected BIM projects (P1, P2 and P3). All three projects used BIM throughout the entire process, not only for important components. This illustrates that the consultants used BIM throughout the implementation and operation of the project, from its inception to its completion. Participants were selected from the administrative and technical levels of each project.

No.	Project/Organisation activities
1	Establishing BIM standard and common practice (standard, technical codes and object-oriented classification for Architect, C&S, M&E, QS and FM
2	Building a reference document aiming at providing a unified BIM standard/methodology/convention/required level of details that can be easily adopted to suit different projects with reasonable modification
3	CAD to BIM migration along the construction value chain (Design, construction and FM). To standardise and formulate standards, guidelines and procedures to the required level of development (LOD)
4	Promoting the adoption of BIM throughout the construction supply chain in the project
5	Accreditation for certification of completed BIM project and BIM user (Architect, C&S, M&E, QS and FM) by BIM certification and qualified body (to be appointed)
6	BIM implementation to the entire project without restriction only on certain activities. Achieve at least Stage 1 of BIM, transition from 2D to 3D
7	Achievement of the BIM project performance (time, cost and quality) all three or any of it

Table 3.
Building information modelling (BIM) project criteria

P1 is a complex hospital construction project with three phases and the addition of new facilities. The project was anticipated to be finished in 2020. This hospital's design and visualisation were based on three-dimensional (3D) graphics, and it is the first in the country to use BIM in its entirety. The hospitals would be able to service the local population of 200,000 with the addition of an operating room, X-ray room, intensive care unit, outpatient treatment room and haemodialysis unit. The primary objective of using BIM for a project is to remove errors during the design phase, thereby preventing wasteful expenditures.

In 2017, this enormous rail-based public transportation project (P2) was successfully completed. Additionally, this project was acknowledged and certified as a Level 2 BIM project. This project's developer was the first in the region to receive BIM Level 2 accreditation in accordance with worldwide standards. BIM Level 2 involves the use of 3D models and information that are shared with all project stakeholders via a single common data environment database, thereby maximising the control and accuracy of project data from the conception and design phase through construction and completion. This project's BIM objective was to minimise design conflicts to avoid costly repairs in the future. Using this platform, about 1,000 conflicts were identified and resolved prior to the MRT site's construction. This prevented unnecessary labour and costly recovery.

P3 is a residential and commercial mixed-use complex. The completion of the commercial facilities was scheduled for 2020, whereas the completion of the residential apartments was expected for 2018. P3 was constructed by one of the largest construction companies in the country, which was also an early adopter of BIM. The primary rationale for implementing BIM on this project is that the team believes it would increase efficiency while reducing material waste. Table 4 summarises the BIM project chosen for this investigation, as reported by CIDB.

3.3 Participants

Respondents were selected for this study based on their BIM experience and knowledge acquired via active engagement in Malaysian BIM projects. *The respondents were also selected because they participated in the selected case study initiatives*. Only individuals who have worked on BIM projects in Malaysia are qualified to address the present state of BIM in the industry and their concerns. This case study focuses on important construction industry stakeholders who have been directly or indirectly involved in BIM projects in

Project ID	BIM project 1 (P1)	BIM project 2 (P2)	BIM project 3 (P3)
Location	Perak	Sungai Buloh	Kuala Lumpur
Type of Client	Public project (Government)	Public project (Government)	Private
Procurement Approach	Design-in-house	Design and Build, Project Delivery Partner	Traditional
Type of Infrastructure	Malaysian Government Hospital	The first line of the KVMRT (Railways)	Integrated Project (Residential and Retail Mall)
Level of BIM Implementation	BIM Level 1 and 2	BIM Level 1 and 2	BIM Level 1
Completion Status	Completed in 2021	Completed in 2017	Completed in 2020
BIM implementation to entire project	Entire project. Achieved at least Stage 2 of BIM, collaboration-based modelling stage	Entire project. Achieved at least Stage 2 of BIM, collaboration-based modelling stage	Entire project. Achieved at least Stage 1 of BIM, design-based modelling stage

Table 4.
Background of selected case studies

Malaysia. This group brings together architects, consultants, BIM consultants, PWD representatives and other functional parties to generate ideas for using the BIM interface to overcome BIM project hurdles in Malaysia. *BIM professionals with at least three years of experience with BIM-related projects were subjected to extensive interviews*. In the English-language in-depth interviews, six employees from three distinct organisations participated. They are all proficient in BIM applications for their respective projects.

Respondent 1 (R1) possessed substantial BIM expertise due to his participation in establishing the BIM implementation plan for his organisation. R1 was also the leader of his company's BIM team and a BIM speaker for numerous construction-related companies, colleges and organisations. Even though Respondent 2 (R^2) is younger than Respondent 1, he is the best BIM modeller for Respondent 1 (P1) and his company. As all of his company's projects use BIM, he is a viable candidate for this interview. Since the start of his career, he has been involved in BIM projects. *Respondent 3 (R3) comes from a private organisation that uses BIM extensively, serving as a model.* R3 was relocated to P2 after more than a year had passed. However, he remained until the project was done and turned over. R3 is an expert in BIM infrastructure, particularly in relation to M&E projects. Owing to his current position, R3 is also proficient in residential BIM projects. Due to his great interest in technology and innovation, R3 is among the organisation's young BIM professionals. Since BIM's introduction in 2017, these three businesses have been among the most eager adopters of the technology.

Respondent 4 (R4) has the most professional experience. R4 is a skilled civil engineer, and he was chosen as the project manager. R4 has forty years of experience working on several projects, including international projects in India, Pakistan and other countries. He was mostly involved with huge construction projects, such as power plants, airports and highways. His work with BIM has grown over the past four years. His organisation relies on him for assistance with the implementation of BIM for P3 and other projects due to his vast experience in anticipating potential obstacles that BIM may detect before they manifest. R5 is ostensibly younger than R4, although she has extensive knowledge of BIM technologies. She is the best BIM modeller in the company. R5 is introduced to BIM upon beginning her employment. This is her second BIM project, the first being the organisation's pilot BIM project. She develops in conjunction with the company's BIM development. Respondent 6 (R6) is the senior respondent after R4 and is a certified quantity surveyor (QS). R6 has participated in numerous projects throughout the years. Prior to the previous three years, he had been unfamiliar with the BIM idea. Since that time, R5 has been competing to grasp and implement BIM. R5 is a key advisor in his company's BIM endeavours in terms of cost and quantity. In addition to P3, R6 has served as a QS consultant on hospitals and significant commercial BIM projects. Table 5 provides the participant profiles of those who participated in the interviews.

4. Data collection and analysis

Interviews with a semi-structured approach were used to extract information from the three selected case studies. In April 2019, the interviews were conducted mostly in the Klang Valley in Wilayah Persekutuan. This case study focused on the major participants in the Malaysian construction industry who have participated in BIM projects. The interviewees were questioned according to the pre-planned interview questions, with extra follow-up questions provided following each response as necessary. The selection criteria for participants included more than five years of experience in the construction industry, at least three years of experience in BIM-related projects, relevant educational credentials and a solid understanding of BIM in construction projects. The objective of the interviews was to

Code	Type of organisation	Position	Educational qualifications	Experience in construction (Years)	BIM experience (years)	BIM projects involved	Case study involved
R1	Government Department	Senior Assistant Director	Masters	12	7	4	P1
R2	Government Department	Engineer (BIM Modeler)	Masters	7	4	3	P1
R3	Contractor	Mechanical and Electrical Engineer	Bachelors	7	4	2	P2
R4	Private Property Developer	Project Manager	Masters	32	4	3	P3
R5	Private Property Developer	Architect	Masters	7	4	2	P3
R6	Private Property Developer	Quantity Surveyor	Bachelors	30	3	3	P3

Table 5.
Profiles of participants taking part in interviews

identify the key obstacles to BIM implementation on local projects and the strategies used to overcome them.

Each participant's responses were coded and then categorised into themes and subthemes for the study. According to Gray (2009), qualitative data analysis entails an understanding of the data in terms of the theory and not simply it is summary. Nvivo11 software was applied in this study as a content-analysis approach for the data gathered during the interviews. In qualitative research, content analysis is an efficient method of data analysis. However, Gray (2005) asserted that this method does not demonstrate the relationship between the variables in the study. The case study was reviewed and discussed using content analysis based on the interview results.

5. Results and discussion

In this section, the relevant themes that are considered important to this research outcome have been identified and analysed. Table 6 lists the themes that have been generated from the interviews.

According to the obtained data, as indicated in Table 6, the primary barriers identified by respondents in this study include time and monetary management and the implementation of change in practice. According to Ayinla and Adamu (2018), the cost is a significant barrier to BIM adoption, while Eadie *et al.* (2013) identified the cost of the BIM process and investment in software, hardware and training as barriers to BIM adoption. As R1 and R^2 stated in P1:

> Our present project's cost increased by 20%, and we continued to engage additional employees, such as BIM specialists and professionals in management. Additionally, we also send some staff members for training. In terms of hardware and software costs, this is why you must first determine which software benefits your organisation and then determine if the software is inexpensive or expensive. If something is costly, determine whether it is worthwhile.

Themes	Categories	Respondents R1	R2	R3	R4	R5	R6
Barriers faced during the application of BIM	Interoperability			/			
	Time and financial review	/	/	/	/	/	/
	Teamwork and Partnership		/	/	/		/
	Client's request						/
	Adoption of change in practice	/	/	/	/	/	/
	BIM Execution Plan (BEP)	/	/	/	/		/
	BIM Utilisation	/		/		/	
Strategies taken to overcome the barriers and to adopt BIM in their project	Collaborative development by training	/	/	/	/	/	/
	BIM education	/	/	/	/	/	/
	Customise BIM execution plan	/	/			/	
	Provision of legislation	/	/				
	Government support					/	
	Technology and provision of trial software	/	/			/	

Table 6. Themes generated from the interviews

The next *barrier* is the time review. The organisation is constrained by a considerable time limitation when it comes to BIM. To ensure that an organisation can withstand innovation, such as BIM, a significant amount of time will be required, and this is viewed as a time-sensitive development project test (Zainon *et al.*, 2020). Moreover, based on the interview data, dealing with people and their attitudes towards technology and innovation is a significant obstacle. It is challenging to persuade associates and top management to adopt BIM when the workforce is accustomed to using the conventional way to complete project requirements. As R4 stated in P3:

> Convincing our staff to adopt BIM is also a difficult task. The first step is to invest in their training. Most importantly, convincing them to give up AutoCAD is challenging.

This study verifies the findings of previous research indicating that certain organisations are sceptical of BIM due to the modifications necessary for its efficient adoption. Similarly, Saka (2019) found that people- and process-related impediments, specifically training-related challenges and the adoption of practise adjustments, are among the most significant obstacles facing the AEC in developing nations. As R3 stated in P2:

> Because the site's users come from various disciplines and mindsets, they are accustomed to two-dimensional (2D) drawings that do not fit the 3D models. They despise the 3D models. When we attempted to execute and explain the 3D model to the subcontractors, they opposed the use of 3D models. Previously, they needed 2D drawings and visualised them on their own, whereas now, we can visualise the model; nonetheless, the requirement for 2D drawings remains. By contrast, the younger generation is technologically adept, and they are willing to accept BIM. However, the elderly are inextricably linked to AutoCAD and traditional methods of working. Thus, BIM increases the capability of the elderly in comparison to youngsters.

The subsequent barriers will involve teamwork and collaboration. Teamwork is the most important success factor for any construction project, but especially for a BIM project comprising a variety of professionals. This reveals that, although being a fundamental goal of BIM, transparency and collaboration among BIM project team members have not been achieved (Awwad *et al.*, 2020). As R6 indicated in P3:

> The construction sector is constantly engaged in a blame game. As an example, there is always a delay in the receiving of architectural and engineering drawings, which inhibits the quantity surveyor (QS) from doing a quantity takeoff; moreover, there is always an imminent need expressed by the client to complete the estimation in a short period of time. Nowadays, we have started to perform quantity takeoff without waiting for both drawings. We begin with any of the drawings that we received initially. For instance, if the structural drawings were obtained, we would proceed with the reinforcement measures. However, when we obtain the architectural drawings later on, there is a frequent discrepancy between them. When we put two drawings on top of each other, the drawings will not be coordinated. There will be a lot of inconsistency in the drawings. This demonstrates a lack of collaboration and coordination among practitioners. BIM aims to reunite the entire team. Eventually, this is what happens in reality.

Although the examined literature indicates the contrary, interoperability is one of the least challenging factors in the adoption of BIM. As R3 observed in P2:

> The consultant produces the drawing in AutoCAD and then converts it to Revit 3D. Therefore numerous details are missing because they were not included in the initial 3D model. However, the consultants these would have a minimal impact. After they handed us the model, we discovered that we needed to remodel it. This saved us some time. Several consultants are still converting 2D to 3D drawings rather than creating the 3D drawings directly. Thus, onsite construction may have certain inconsistencies, making it less accurate in areas where we need to identify a way to make it more accurate.

Another aspect that is frequently overlooked is the client's request. Other scholars have suggested that client demand is no longer a significant factor, likely because of the government's effort to make BIM mandatory for projects beyond RM50 million, as stated in construction industry transformation plan (CITP) 2016–2020 (CIDB, 2017). As R3 clarified in P2:

> We (consultants) subscribe to BIM in advance, but not all of our clients want their project values to be linked through BIM. However, a few of them are prepared to employ BIM, most likely owing to a lack of client requirements and demand.

As an essential guideline for BIM execution, the next concern is the establishment of standardised BIM processes across the country. Other respondents claimed that without a clearly defined BIM execution strategy, the organisation would be unable to meet its BIM objectives. This conclusion corroborates Salman Azhar's (2012) assertion that the majority of organisations use their own procedures, which results in discrepancies and inaccuracies in BIM models. The lack of standardisation leads to the use of non-standardised methods. As R1 stated in P1:

> The government proposed a BIM execution strategy earlier, but it is not appropriate for all types of projects, which vary in complexity and design and serve a variety of purposes. For instance, infrastructure projects will be executed differently than residential construction. We do not have a set of procedures or BIM protocols, or even a BIM execution plan.

One genuinely new barrier identified in this result (which was not identified in the review of the literature) is the underutilisation issue, which may be a key cause of all the other barriers. R3 went into detail about the struggle with this issue in his P2:

> They did not fully utilise it because it increased the consultant's workload. BIM helps address a lot of problems. However, before we began our previous project, we had both an official and an unofficial kick-off meeting with the consultants. They stated that they had previously coordinated the model, and it was ready to go ahead. However, when we received the model, there were several issues. I feel that they did not coordinate among themselves, and that it was only after they discovered the problem that the consultants began to discuss it. Before the consultants

formulate their report, all project information – including minor data – should be loaded into the software. However, this is not frequently the case; just the key information is input into the software. As a result, the client and building users will receive an insufficient asset management database, thus undervaluing BIM projects. When BIM is used properly, numerous benefits arise.

According to the findings, cost and time constraints, as well as the adoption of new practices, have emerged as the most significant barriers to BIM adoption. The findings are summarised in Table 7.

Figure 1 summarises respondents' perspectives on the barriers confronting BIM adopters.

Table 7 shows that the effective approaches for the successful implementation of BIM were training and BIM education. Training has a critical role in influencing individual attitudes; constitutes one of the primary tools for addressing human-related barriers; and is supported by previous studies (Ezeokoli *et al.*, 2016; Marefat *et al.*, 2019; Oraee *et al.*, 2019; Saka *et al.*, 2019). As stated by R3 in P2:

> To address human-induced issues, we often send our staff on training and also keep track of comparable BIM projects to use as a benchmark. We often travel internationally to do so. Additionally, we have our own expert on BIM throughout the training process. It establishes a competitive circle for BIM projects. The top management's initiative must be present. Without the top management's willingness to invest in software, even if we provide free training that is not useful, it will be a waste of time. Thus, training sessions and practical usage sessions are both important.

BIM education is also critical for integrating the next generation into the globally competitive construction sector, as they are the industry's future leaders. As information technology advances, the requirement for BIM expertise increases. A lack of BIM-trained professionals is the leading global impediment to BIM deployment in institutions (Mbugua, 2022). According to a report by Belayutham *et al.* (2020), integration of BIM into higher education will help enhance AEC's BIM adoption and address the current scarcity of competent BIM practitioners. As stated by R1 and R^2 in P1:

> BIM must be introduced into the curricula of relevant groups of students, primarily those enrolled in construction-related courses. If they previously used AutoCAD, they should switch to BIM instantly. Collaboration between construction practitioners and the Ministry of Education (MOE) is critical. As an example, several institutions offer BIM as an elective subject, and interested individuals can attend training for free, thereby securing a better career. BIM education is one of the most successful methods used for absorbing and increasing the use of BIM.

Furthermore, in addressing the high cost of BIM software, it is beneficial to use technology and trial applications to overcome the BIM barrier. The majority of respondents were aware that the government effort provided free software and training, which is a positive approach (MYBIM, 2021). As mentioned by R1 and R^2 in P1:

> Free training is offered to everyone, with facilities for training and trial software organised in MYBIM centres. To address the issue of pricey software, users can use approximately 15 different applications during the trial term of BIM software. One can then choose the appropriate programme for their primary goal. Initially, BIM software was prohibitively expensive. However, the cost has decreased considerably. Therefore, the trial version can be used to determine which software applications are necessary for your type of project or for achieving your organisation's aim.

In terms of BIM usage legislation, respondents believe that the technology will spread throughout Malaysia only if legislation is passed. Only a few large companies use BIM, whereas, in the public sector, projects costing more than RM100m are required to use BIM (effective since 2019) (Bernama, 2019). As indicated by R^2 in P1:

Case studies	Code	Barriers faced by BIM adopters
Malaysian Government Hospital	P1	• Cost increases due to the initial stages of BIM adoption (hiring new personnel, procuring software and hardware and training) • It requires a lot of time to convince individuals to accept BIM and forgo traditional methods, as well as time to acquire a new setup for new working methods • People-oriented barriers (changing people's mindsets) • Teamwork and collaborative effort among construction sector actors are still insufficient • BIM features are not being used to their full potential since additional effort is required, and hence, the full benefits are not realized • The absence of a clear procedure for BIM adoption is a significant issue. Each organisation has its own BIM protocols and workflow • Similar barriers addressed by all BIM projects
The first line of the KVMRT (Railways)	P2	• Interoperability issues arise when consultants create drawings in AutoCAD and then convert them to Revit 3D, resulting in missing items when the drawings are opened in another BIM programme • Cost increases due to the initial stages of BIM adoption (hiring new personnel, getting software and hardware and training) • It takes a long time to convince individuals to accept BIM and forgo traditional methods, as well as time to acquire new setup for new working methods • People-oriented barriers (changing the mindset of people, especially the elderly community) • Collaboration and teamwork are still insufficient among construction industry stakeholders • BIM features are not used to their full potential since additional effort is required; the full benefits are not realised • The absence of a clear procedure for BIM adoption is a significant issue. Each organisation has its own BIM protocols and workflow • Similar barriers are addressed by all BIM projects
Integrated Project (Residential and Retail Mall)	P3	• Increases overall project costs (hiring new employees, procuring software and hardware and training) • It requires a lot of time to convince individuals to accept BIM and forgo traditional methods, as well as time to acquire new setup for new working methods • People-oriented barriers (changing the mindset of people) • Even level-one employees are unaware of what is happening in a BIM project; only the BIM expert is informed of its progress, so there are undoubtedly collaboration barriers • The client should drive all consultants to use BIM; this requires a push from the client • There is a lag in fully using BIM as it evolves daily • The absence of a clear procedure for BIM adoption is a significant issue. Each organisation has its own BIM protocols and workflow • Similar barriers are addressed by all BIM projects

Table 7.
Barriers faced by BIM adopters

> It is a commendable attempt by the government to enforce the required use of BIM for projects valued at more than RM50 million. To support the program, the government announced that projects utilising BIM will receive intensive and free training in CITP 2016/2020.

Although respondents did not all indicate governmental support, it is critical considering that they are Malaysia's most active BIM users with substantial BIM project expertise. As stated by R5 in P3:

> Like small businesses, it is difficult for them to transition to BIM unless the government subsidises, but they have already provided some cost subsidies, which should be extended.

One emerging and extremely beneficial outcome of the research is in the form of customised BIM execution plans (BEPs), which could address the aforementioned barriers. As R1 and R^2 explicitly stated in P1:

> Developing a strong execution plan is critical. Only then can we have confidence in initiating a BIM project. Typically, a BIM manager is responsible for developing the BEP. The BIM manager is responsible for planning it in accordance with the client's specifications. As with our projects, the contractor must generate project data, such as deliverables, clash detection, and the submitter of the model. The submitter of models would be a list of all consultants associated with the project. The BPE is an all-inclusive planning process. The contractor will be successful in adopting BIM provided he adheres to the execution plan.
>
> Apart from that, a successful business process re-engineering (BPR) for BIM requires a detailed road map for achieving the benefits of BIM. For instance, the BPR may contain an exclusive road map outlining a timeframe for resolving all the barriers that arise during the timeline. It will advise on the length of time required to conduct awareness training if the issue is human-related. In terms of technology, we must stay current on software and hardware releases. Nevertheless, the entire process is dependent on the client's specifications. In this way, we can develop a BIM standard for facility management.

Additionally, R5 stated in P3:

> Several modules of the BEP should be developed for different types of BIM projects. For example, infrastructure, residential, and railway projects each need to have their own BEP. To support these types of projects, at least two distinct BIM execution plan modules need to be developed. The framework built will be tremendously beneficial in planning future BIM projects and will serve as an important source of asset management for the client.

As stated in this section, collaborative growth through training is equally as important as embedding BIM education among younger construction actors to successfully integrate

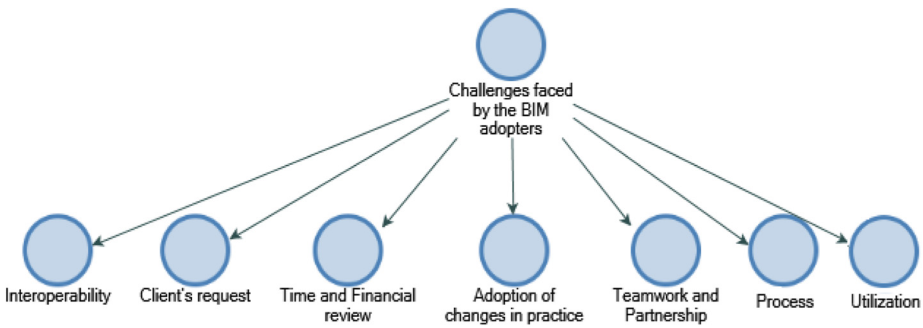

Figure 1. General summary of respondents' views on barriers faced by BIM adopters

BIM in the Malaysian construction sector and thereby ease the constraints that BIM adopters now face. The findings are summarised in Table 6 (Table 8).

Figure 2 summarises respondents' views on strategies to overcome the BIM barriers.

6. Conclusion and recommendations for future research

To expedite the implementation of BIM in construction projects, collaborative development through training and BIM education is necessary. Therefore, organisations must provide adequate training to their employees in order for them to leverage government-provided BIM training to increase BIM adoption. Additionally, BIM should be incorporated into higher education so that students who predominantly work in the built environment domain can acquire core BIM knowledge and skills that will prepare them for the real world, hence, increasing the current BIM adoption rate. Furthermore, because BIM is a medium for the

Case studies	Code	Strategies implemented in the case studies to overcome barriers
Malaysian Government Hospital	P1	• Create awareness through *training,* creating champions in one's own organisations (Change Management) • It is important to know which software to purchase; hence, usage of *trial* software is important • Roadmap/BEP is very important to overcome the barriers not just for implementation but for Facility Management (FM) as well • Implementation of legislation has aided significantly in raising demand for BIM • Government incentives granted as part of CITP 2016/2020 for BIM adopters have increased awareness of BIM and the motivation to embrace it • It is critical for Malaysia's education system to incorporate BIM into tertiary students' curricula, as they will be replacing older generations in the sector, hence promoting BIM adoption
The first line of the KVMRT (Railways)	P2	• BIM education in academia is crucial for the design students (Architecture and Civil and Structural) but not for Mechanical and Electrical students as they are not involved much during construction • Training is critical as part of the plan for BIM deployment
Integrated Project (Residential and Retail Mall)	P3	• A roadmap/BEP is critical for stating the target objective and staying on track • It is critical for Malaysia's education system to incorporate BIM into tertiary students' curricula to increase employability and BIM adoption • Government incentives and cost subsidies granted to BIM adopters under CITP 2016/2020 have raised awareness of BIM and the motivation to adopt it • It is critical to know which software to purchase, which is why trial software is important • Training is critical as part of the plan for BIM deployment

Table 8. Strategies implemented in the case studies to overcome the barriers

globalisation of the construction industry, it is vital to design a BIM execution plan that fits with international benchmarking standards and provides a guideline for local construction operators. To achieve the goal of the national CITP, the construction industry must foster changes in construction operators' practises towards a more innovative industry. The study concludes that time and cost constraints have the greatest impact on BIM adoption. This research contributes to a greater knowledge of the essential aspects impacting BIM adoption and future strategies.

This study fills a gap in the existing body of literature by investigating the actual barriers BIM adopters in Malaysia experience and the strategies they use to overcome them. This study examines actual BIM challenges and how they have been addressed by various construction project types and clients. Thus, academics and researchers may use these strategies to develop frameworks for promoting BIM adoption. In addition to the previously mentioned approach, the latent approaches presented in this study may pique academics' interest, resulting in future studies on AEC firms' participation in BIM deployment. While various BIM challenges, including proposed methods, are prominent and significant, as discussed in the existing literature, their impact on actual projects is negligible. Consequently, training and education in BIM should be addressed to increase BIM's adoption across building projects. This is a crucial consequence, as it identifies particular developmental measures that should be implemented to aid organisations in expanding their BIM usage and reducing wasteful expenses. This study provides a comprehensive evaluation of BIM implementation barriers and strategies for local construction projects. Due to the absence of evidence on actual BIM project barriers and methods for overcoming them, organisations should prioritise this study by focusing on staff training, while institutions should incorporate BIM education for built environment students. Moreover, by examining the obstacles and pertinent strategies for overcoming them, a comprehensive understanding of the underlying structure of the BIM barriers is provided, thereby enabling a chief executive officer or managing director of an organisation to become aware of the underlying issues and how to address them.

Despite the significance of these findings, this study has limitations that must be addressed in future investigations. These limitations include the fact that only three case studies were investigated, making it unable to generalise the findings, and that only a qualitative method was used in this study. Besides, data were analysed from the Malaysian perspective. Therefore, the findings should be applied selectively and with the necessary modifications to other nations. Consequently, a broader scope of data collection across nations and regions can contribute to the creation of strategies to promote BIM adoption. Nonetheless, the results of this study provide valuable insight into BIM construction

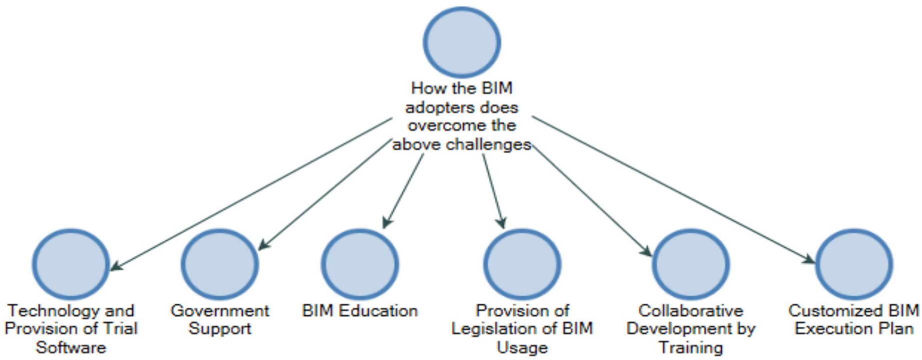

Figure 2. General summary of respondents' views on strategies to overcome the BIM barriers

projects. Future research can use a mixed-method approach to investigate BIM challenges and potential solutions to produce a more comprehensive implementation strategy.

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