EXPLORE BUILDING INFORMATION MODELLING (BIM) APPLICATION AND PERFORMANCE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

KOH YEN ZI

UNIVERSITI TUNKU ABDUL RAHMAN

EXPLORE BUILDING INFORMATION MODELLING (BIM) APPLICATION AND PERFORMANCE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

KOH YEN ZI

A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying

Lee Kong Chian Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

September 2024

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

Signature :

Name : Koh Yen Zi

ID No. : 1905950

Date : 12/9/2024

APPROVAL FOR SUBMISSION

I certify that this project report entitled **"EXPLORE BUILDING INFORMATION MODELLING (BIM) APPLICATION AND PERFORMANCE IN THE MALAYSIAN CONSTRUCTION INDUSTRY"** was prepared by **KOH YEN ZI** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying at Universiti Tunku Abdul Rahman.

Approved by,

Signature : Ooi Kean Thong

Supervisor : Dr. Ooi Kean Thong

Date : 7/10/2024

Signature : ________________________

Co-Supervisor : ________________________

Date : ________________________

The copyright of this report belongs to the author under the terms of the copyright Act 1987 as qualified by Intellectual Property Policy of Universiti Tunku Abdul Rahman. Due acknowledgement shall always be made of the use of any material contained in, or derived from, this report.

© 2024, Koh Yen Zi. All right reserved.

ACKNOWLEDGEMENTS

I want to thank everyone who helped make this study successful. I am especially grateful to my research supervisor, Dr. Ooi Kean Thong, for his valuable guidance and patience throughout this process. I also appreciate the support of my parents and friends who encouraged me along the way. A big thank you to all the interviewees and questionnaire respondents who took the time to share their insights and contribute to this research. Your participation has been crucial to the success of this study.

ABSTRACT

Building Information Modelling (BIM) has experienced significant growth in the global construction sector, including in Malaysia, over recent years. This study explores BIM's application and performance in the Malaysian construction industry by focusing on three key objectives: assessing the current level of BIM application, identifying barriers to its adoption, and proposing solutions to enhance its utilization. A comprehensive literature review highlighted 12 major challenges and 10 significant solutions to increase adoption. Data was collected through an online survey of 161 industry practitioners, analyzed using Cronbach's alpha for reliability and the Kruskal-Wallis H-test to evaluate differences based on company size, profession, and work experience. Semi-structured interviews with nine industry professionals provided additional insights. The study found that BIM is predominantly implemented at Levels 1 and 2, with significant barriers including technological complexity, high costs, and a shortage of skilled professionals. Recommended solutions include increasing organizational training, enhancing government support, and addressing broader economic factors. These findings aim to aid the industry in advancing BIM adoption, inform regulatory policies, guide academic curriculum development, and improve software solutions, thereby aligning Malaysia’s BIM practices with global standards. Moreover, this research underscores the need for a consistent strategy involving all stakeholders to overcome current challenges and drive sustainable BIM integration. The research gap lies in the lack of comprehensive, mixed-method studies that explore the latest barriers and practical solutions to BIM adoption across both the public and private sectors in the Malaysian construction industry, particularly involving key professionals like architects, engineers, and BIM coordinators.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS / ABBREVIATIONS

AI	Artificial Intelligent
AR	Augmented Reality
AutoCAD	Automatic Computer Aided Design
B	Barriers
BIM	Building Information Modelling
CAD	Computer-Aided Design
CIDB	Construction Industry Development Board
F	Familiar
IoT	Internet of Things
IPD	Integrated Project Delivery
ISO	International Organization for Standardization
JKR	Public Works Department
LOD	Level of development
MRT	Mass Rapid Transit
PC	Personal Computer
QS	Quantity Surveying
R	Respondents/Interviewee
R&D	Research and development
RICS	The Royal Institution of Chartered Surveyors
ROI	Return on investment
S	Solution
SME	Small and medium-sized enterprises
SPSS	Statistical Package for the Social Sciences
TAS	Cubicost Take-off for Architecture and Structure
TRB	Cubicost Take-off for Rebar
UK	United Kingdom
VR	Virtual Reality

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Since the pandemic, technology has become increasingly vital in the construction industry (RICS, 2020), enabling smoother project execution from start to finish. Among these innovations, Building Information Modelling (BIM) stands out as a highly effective tool that enhances efficiency throughout all stages of construction (CIDB, 2023). BIM is a comprehensive process for creating and managing information across the lifecycle of built assets (Hamil, 2021). It leverages shared digital representations of structures, such as buildings, bridges, and roads, to facilitate design, construction, and operations (Song et al., 2023). By generating detailed 3D models enriched with smart data, BIM fosters collaboration and supports decision-making from planning through maintenance (Rane, 2023). In Malaysia, BIM is transforming construction project management, offering efficient life-cycle management that boosts productivity and sustainability (CIDB, 2022).

While BIM has been widely adopted in countries like the United States, Australia, Hong Kong, Denmark, Norway, Finland, and Singapore due to its resource efficiency benefits across design, construction, and maintenance (Mustaffa et al., 2017), Malaysia still lags in adoption. Governments in developed nations, such as the U.S., Singapore, and Australia, have actively promoted BIM through national programs, training, and mandates in government projects (Mustaffa et al., 2017; Cheng and Lu, 2015). For example, Singapore's Building and Construction Authority (BCA) has promoted BIM since 1997, contributing to significant adoption increases, like the UK's rise from 13% to 73% between 2011 and 2020 (NBS, 2020).

However, compared to these leading countries, Malaysia has room for improvement in BIM adoption (CIDB, 2021). While global challenges such as time, cost, and design issues persist, Malaysia faces unique barriers, both technical and non-technical. Non-technical challenges, such as organizational culture, and technical barriers, like technology integration, impede BIM application (Enegbuma et al., 2014). Unlike developed countries, Malaysia struggles with individual readiness for BIM adoption (Usman, 2015). Despite BIM's potential, its use in Malaysia is mainly limited to the schematic design phase by architects and engineers (Onungwa and Uduma-Olugu, 2016; Banawi, 2017). Ahlam and Abdul Rahim (2020), Feng (2021), and Othman et al. (2021) confirm that BIM remains in its early stages in Malaysia, though Feng (2021) emphasizes its transformative potential once fully implemented. Conversely, Wong and Gray (2019) highlight the difficulty of overcoming reliance on traditional methods, a key barrier to BIM adoption in Malaysia. Othman et al. (2021) further report that BIM application remains at only 13% across both public and private sectors.

Additionally, there is a noticeable lack of documented evidence showcasing construction stakeholders' engagement in BIM-utilizing projects. Despite government efforts to promote BIM through policies and mandates, its adoption rate remains slow across the industry (Yasser et al., 2019). In 2021, BIM usage increased to 55%, up from 49% in 2019, while awareness rose to 78%, compared to 74% in 2019 (CIDB,2021). The Malaysia Public Works Department (JKR) Strategic Plan 2021-2025 targets 80% BIM adoption by 2025, but many contractors and engineers hesitate to fully integrate BIM unless explicitly mandated by project owners (Chuah, 2024; Miza, Tee, Nazir, 2023). Basir (2023) found that the construction industry contributed 8.7% to GDP growth in 2022, yet Malaysia lags behind Europe and North America in BIM research and integration (Saka and Chan, 2019b), further slowing progress.

Addressing these barriers is crucial for advancing BIM adoption in Malaysia's construction industry. This research investigates the current state of BIM application and performance, focusing on the unique challenges that hinder wider adoption compared to developed economies. It also explores stakeholder engagement in BIM projects to identify opportunities for enhancing BIM utilization and achieving optimal project outcomes.

1.2 Problem Statement

The Economic Planning Unit (2021) highlighted that one of the key reasons for the construction sector's low productivity is the slow adoption of digital tools like Building Information Modelling (BIM). In recent years, government initiatives have added urgency to the BIM adoption challenge. Deputy Works

Minister Datuk Seri Ahmad Maslan announced that starting August 2024, BIM would be mandatory for all public and private projects valued at RM10 million and above. As of September 2024, this mandate extending to infrastructure projects like roads and sewage systems. These announcements show the government's increasing awareness of BIM's importance and its push for broader adoption across the construction sector. However, despite the mandate, there has been limited research evaluating the current applications, challenges, and solutions for achieving Malaysia's BIM goals.

Several past studies have focused on BIM adoption challenges in the Malaysian construction industry. Zaini et al. (2020) identified key elements like BIM awareness, benefits, challenges, and strategies for adoption in Sarawak's construction industry through literature reviews and surveys. Tanko, Zakka, and Heng (2021) explored the role of BIM in reducing construction waste and improving productivity using a scientometric analysis of 244 records from Scopus and a structured questionnaire sent to 100 practitioners. Sriyolja, Harwin, and Yahya (2021) systematically reviewed 26 journal articles and conference papers published between 2013 and 2019, identifying 15 categories of barriers to BIM adoption, including cost, legal issues, lack of expertise, and interoperability. Munianday, Rahman, and Esa (2022) conducted in-depth interviews with three BIM projects in Malaysia to explore challenges like time constraints, financial issues, and resistance to change, using NVivo for qualitative analysis. Yaacob et al. (2024) focused on BIM adoption barriers among civil and structural engineering consultants through a survey of 30 consultants, revealing high costs, legal concerns, and software complexities.

While these studies have provided valuable insights, there remains a significant research gap, particularly in understanding newer barriers, such as client awareness and industry issues. Most existing studies have focused on isolated regions, without conducting comprehensive mixed-method research across both the public and private sectors. There is also a lack of updated analysis that takes into account the perspectives of architects, engineers, and BIM coordinators, who play key roles in the application process. Moreover, recent government mandates have not been thoroughly examined in relation to the current state of BIM adoption. Addressing these gaps is now more critical than ever. As the government pushes for wider BIM adoption through new policies, understanding the latest barriers whether technical, financial, or regulatory is essential for ensuring Malaysia meets its 2025 BIM adoption goals. If these challenges are not addressed, the construction sector risks falling behind, which could negatively impact project efficiency, sustainability, and overall competitiveness. This research intends to provide timely insights to help the industry align with government policies, streamline project workflows, and ultimately boost productivity.

This study aims to explore BIM application in the Malaysian construction industry, focusing on current and future barriers, and offering practical solutions that address the latest challenges to improve BIM adoption. The inquiries that this study aims to addressed are there any unique findings regarding the current challenges of BIM adoption, and how can these challenges be addressed to ensure Malaysia meets its 2025 BIM adoption targets? What practical solutions can be proposed to overcome the existing and anticipated barriers in order to boost BIM adoption? This study is especially important now, given the recent government mandate.

1.3 Research Aim

The aim of this research is to explore BIM application in the Malaysian construction industry.

1.4 Research Objectives

To realise the above-mentioned research aim, research objectives have been established as below:

(i) To examine the current application of BIM in the Malaysian construction industry

(ii) To investigate barriers hindering the process of BIM application in the Malaysian construction industry

(iii) To identify solutions to increase the adoption of BIM in the Malaysian construction industry

1.5 Research methodology

The research will employ a mixed method research, utilise both quantitative and qualitative techniques. Firstly, quantitative data will be collected through surveys. Quantitative method is used to assess the current stage of BIM application in the Malaysian construction sector. These surveys will gather information on the extent of BIM usage and its perceived effectiveness. Additionally, qualitative methods such as interviews and questionnaire will be utilized to delve deeper into the barriers hindering BIM application and to identify potential solutions. With these findings, the research aims to provide a comprehensive understanding of the application and performance of BIM in the Malaysian construction industry.

1.6 Research Scope

This study focuses on gathering data from various professionals in the construction industry in Malaysia, including architects, quantity surveyors, and engineers. All these professionals are current or existing BIM users from all stages of the construction industry, possessing experience that can provide valuable insights into BIM usage.

1.7 Chapter Outline

This research report is split into 5 chapters: Introduction, Literature Review, Research Methodology, Results and Discussion, and Conclusion and Recommendations.

Chapter 1: Introduction

This chapter introduces the topic of BIM in construction. It explains what the research is trying to find out, which is how well BIM works in the construction industry. Additionally, it presents the research objectives, methodology, scope, and structure of the report.

Chapter 2: Literature Review

Chapter 2 gives a clear overview of BIM. It then reviews existing literature on BIM, focusing on its current adoption and future prospects, especially in the Malaysian construction industry. The chapter also discusses the challenges faced in implementing advanced levels of BIM. Throughout this chapter, information is gathered from various sources like books, websites, and journals to support the research topic of exploring BIM application and performance in the Malaysian construction sector. This research aims to assess the current stage of BIM application, identify barriers hindering its adoption, and propose solutions to increase its uptake.

Chapter 3: Research Methodology

This study utilizes a specific research methodology to explore BIM application and performance in the Malaysian construction sector, aligning with the research's aim and objectives. Both qualitative and quantitative approaches were utilized, with a focus on questionnaire design that incorporated both closed and open-ended questions to gather insights from respondents. Data analysis techniques included qualitative methods like Thematic analysis and quantitative method like Cronbach’s Alpha Reliability test. Additionally, ethical considerations throughout the data collection process were addressed, ensuring the integrity and validity of the research findings.

Chapter 4: Results and Discussion

Chapter 4 examines the data collected through questionnaires from construction practitioners in the Malaysian construction sector. It evaluates these responses concerning the research aim and objectives, aiming to achieve the research goal. This chapter analyses the results. Key insights and conclusions drawn from the data are then discussed.

Chapter 5: Conclusion and Recommendations

In this final chapter, the research findings are used to justify conclusions aligned with the study’s aim and objectives. The research's impact on industry stakeholders, regulatory bodies, and academia is explored and discussed. The chapter concludes with reflections on limitations and recommendations for future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Firstly, the research started with introduction and follow by Section 2.2 definition of BIM, Section 2.3 involves current application of BIM in the Malaysian construction industry, BIM maturity level, benefits of BIM. Section 2.4 investigate barriers hindering the process of BIM application in the Malaysian construction industry. Section 2.5 identifies solutions to increase the adoption of BIM in the Malaysian construction industry. Finally, Section 2.6 is Conceptual framework while Section 2.7 is summary.

2.2 Definition of Building Information Modelling (BIM)

Building Information Modelling (BIM) is a process, not just a software tool, that allows teams to create, manage, and share digital representations of construction projects throughout their entire lifecycle from planning and design to construction, maintenance, and even demolition (Sacks, 2018). It integrates both geometric (3D visual) and non-geometric data (such as material properties, supplier information, and warranties) into a single, shared platform, enabling seamless collaboration among all stakeholders involved in the project. While "Building" in BIM often leads people to think it only applies to buildings, the term "building" refers to the act of construction, making BIM relevant to any kind of asset, including infrastructure projects like roads and bridges. "Information" in BIM refers to the structured sharing of both geometric and non-geometric data, such as the dimensions of objects and details like their supplier, fire-rating, or warranty specifications. The term "modelling" refers not just to creating 3D models, but to representing various aspects of the project such as structural, architectural, and operational data, helping stakeholders simulate and plan the entire construction process (The Institute of Structural Engineers, 2021).

BIM is more than a simple design tool. It is a collaborative, model-based approach that facilitates the management of construction data efficiently and effectively across the lifecycle of a project. It allows users to review daily performance against plans, adjust quickly, and make informed decisions, especially on smaller projects (Waqar, Qureshi and Alaloul, 2023). As a technology-enabled process, BIM is flexible and can be applied to both building and infrastructure projects, supporting activities from design to maintenance (Kjartansdóttir, et al., 2017; Afiq, 2020; Ashmori, et al., 2020). BIM emphasis on information sharing makes it crucial for improving project efficiency and decision-making across multidisciplinary teams (RICS, 2022). By consolidating all relevant project documents into one platform, BIM helps ensure better communication, reducing errors and improving overall project outcomes.

The following Table 2.1 shows the definitions of specific terms used in this research.

Table 2.1: Specific Terms

Terms	Definition	Sources
Construction Industry	The construction industry involves the part of manufacturing and trade that deals with building, fixing, upgrading, and taking care of buildings and structures.	Hussain and Nuzhat, 2022
Interoperability	BIM interoperability means that BIM applications can share and work with the same data using common exchange formats, file types, and protocols, like open BIM by smart Buildings.	Shehzad, et al., 2021
Application	The act of utilizing something for a specific purpose or function.	Cambridge Dictionary, 2024
Industry Foundation Class (IFC)	The Industry Foundation Classes (IFC) is an open international standard that enables the exchange and sharing of BIM data between different software applications used by professionals in the	ISO, 2024

	construction and facility management sectors.	
Construction Operations Building Information Exchange (COBie)	Construction Operations Building Information Exchange (COBie) is a standardized data format that focuses on providing asset information from BIM models, rather than geometric data, for better facility management and operations.	Hamil, 2018
Common Data Environment (CDE)	A Common Data Environment (CDE) is a shared digital workspace that provides designated access for different project stakeholders, with clear status updates and structured workflows for sharing and approving information.	Preidel, et al, 2018

2.3 Current application of BIM

In Building Information Modelling (BIM), different dimensions serve distinct purposes to enhance project outcomes. A 3D model improves visualization, facilitates communication of design intent, and promotes multidisciplinary collaboration. A 4D model integrates scheduling for better construction site planning, while a 5D model tracks budgets and supports cost analysis. The 6D model is used for energy consumption analysis, contributing to sustainability efforts. Finally, the 7D model assists facility management teams in maintaining and operating the facility throughout its lifecycle (JKR,2019).

Despite the slow adoption in Malaysia (Othman et al., 2021; Omar, Fateh., 2023), BIM has become a key element of the Malaysia Construction 4.0 Strategic Plan (2021–2025), aiming to accelerate digital construction (CIDB, 2021). For successful application of BIM in construction projects, professionals must thoroughly explore its diverse applications and understand its distinct functionalities at each stage of the project lifecycle. However, according to Zulkifli et al (2024), there is not much research on the application of BIM, and the technology is still relatively new in Malaysia's construction industry. BIM application involves four critical aspects, which are planning, design, construction, and operation.

2.3.1 Planning - Project Visualization

In the application of BIM for project visualization, stakeholders such as clients, architects, engineers, and contractors can comprehensively view a project before construction. Tools like Revit Architecture, Structural, and MEP enable the creation of coordinated 3D models, enhancing collaboration and serving as a central reference for all contributors (Brahim, Latiffi, Fathi, 2018). Instant 3D visualizations of spaces and alternatives allow technical and non-technical staff to quickly evaluate design options. (Kjartansdóttir, et al, 2017).

2.3.2 Planning - Project Cost Estimate

BIM integrates with quantity surveying tools like Exactel Cost-X and Vico Takeoff to automate the extraction of quantities, areas, volumes, and material counts, essential for accurate cost estimation and construction planning. By linking the model to a cost database, quantity surveyors can produce precise quantity takeoffs and reliable cost estimates, enhancing accuracy and streamlining the estimation process (Barnes and Davies, 2014). This approach aids decision-making by providing better visual representations of project elements and facilitating the exploration of design options within budget constraints. Successful application requires a high-quality 3D model, appropriate design software, cost data formats like Uniformat or Uniclass, and an understanding of the model's Level of Development (LOD) (Kjartansdóttir, et al, 2017).

2.3.3 Design - Communication and Collaboration among Stakeholders

In the application of BIM for communication, real-time collaboration among multidisciplinary teams enhances coordination throughout the construction process (Eadie et al., 2015). BIM provides a shared platform where stakeholders work simultaneously, improving transparency and facilitating efficient information sharing. At the planning stage, designers can easily communicate project details to owners and gather feedback based on site analysis, phase planning, and budgets. Additionally, 3D models allow project teams to communicate design ideas to owners and authorities, improving coordination and integration across various trades (Brahim, Latiffi, Fathi, 2018).

2.3.4 Construction - Fabrication of Shop Drawings

In the application of BIM for the fabrication of shop drawings, the process is streamlined by automatically generating drawings from a coordinated 3D model, reducing the need for manual updates typical of 2D methods. Any design changes are reflected instantly in the model, ensuring accuracy and efficiency. Additionally, BIM facilitates digital fabrication by using data from the 3D model to produce materials such as structural steel and sheet metal with minimal waste. This improves fabrication productivity, reduces lead times, and supports real-time adjustments in design, enhancing project quality (Kjartansdóttir, et al, 2017).

2.3.5 Construction - Project Scheduling

In the application of BIM for project scheduling, 4D capabilities integrate time-related data with 3D models, enabling efficient tracking and updating of project progress. Tools like Autodesk Navisworks allow project managers and contractors to simulate construction sequences, optimize schedules, and identify potential clashes, ensuring projects stay on track (Hardin & McCool, 2015). BIM also facilitates the simulation of construction processes by linking building model elements to scheduled activities, helping to identify bottlenecks, enhance collaboration, and perform accurate constructability analysis for improved project feasibility (Brahim, Latiffi, Fathi, 2018).

2.3.6 Operation - Facilities Management (FM)

In the application of BIM for facility management, it provides a comprehensive digital record of building assets, enabling facilities managers to efficiently track and update information on components, fixtures, and equipment (Bonanomi, 2016). BIM supports the ongoing management of both new and existing facilities by storing accurate, up-to-date data, which streamlines maintenance and operational processes (Kensek, 2014). Additionally, BIM captures changes made during construction, ensuring that the as-built model reflects the actual facility, which is crucial for effective facility maintenance and management (Brahim, Latiffi, Fathi, 2018).

In Malaysia construction industry, BIM is predominantly utilized during the pre-construction phase, with minimal application in the post-construction phase (Zulkifli, et al., 2024). As Malaysia adopted BIM mostly for 3D visualization, cost estimation, clash detection, design reviews, and building operation and maintenance (Ahmad Latiffi et al., 2016). Similarly, despite the CIDB's annual efforts to promote BIM among construction professionals, its application remains limited during the construction phase, with most applications concentrated in the design stage, particularly for 3D modelling (Othman et al, 2021).

2.3.7 BIM Maturity level

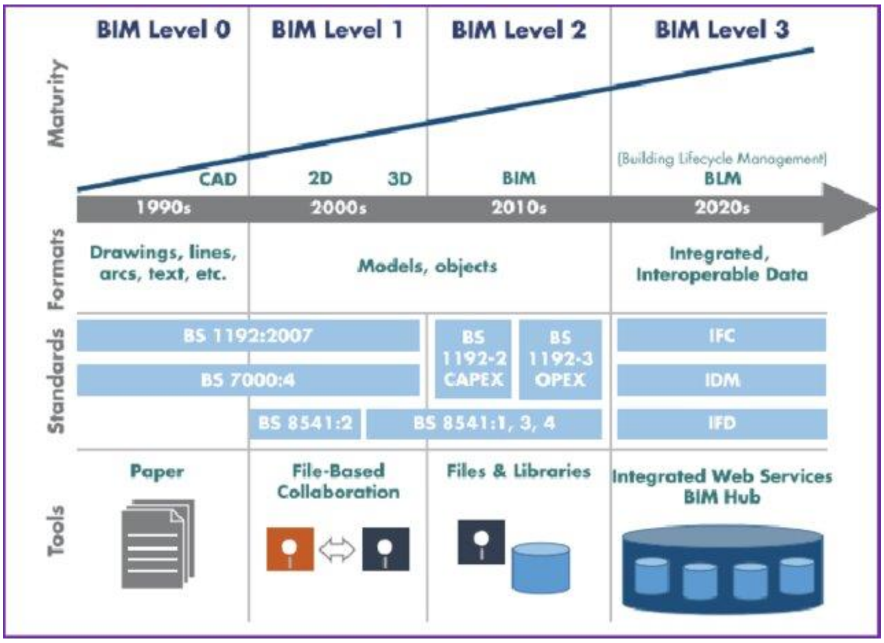

Figure 2.1: BIM Maturity Level (Sacks, et al., 2018)

As show in Figure 2.1, BIM Level 0 involves the use of unmanaged CAD, often limited to 2D drawings. Information is shared in formats like paper prints or digital files (such as PDFs), but there is no real collaboration between project participants. This is the most basic form of BIM and primarily consists of isolated data sets. BIM Level 1 represents partial collaboration, typically involving a mix of 3D CAD for design concepts and 2D drawings for statutory approvals and documentation. Data sharing is managed through a Common Data Environment (CDE), often controlled by the contractor, with specific standards ensuring consistency. While there is some collaboration, data and processes largely remain separate between different disciplines (Richard, 2014; Sacks, et al., 2018).

BIM Level 2 introduces true collaborative working, where each discipline works on its own 3D models, but these are shared and coordinated through a CDE. Models are exchanged using common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange), allowing for better coordination and reducing errors. BIM Level 3 supports full collaboration across all project disciplines, with everyone working on a single, shared model - Open BIM. Data is stored in a centralized environment, allowing real-time access, updates, and modifications by all parties. This enables seamless integration throughout the entire project lifecycle (Richard, 2014; Sacks, et al., 2018). The BIM maturity level in Malaysian construction industry is only in Level 0 and Level 1 (Ashmori, Othman, Aidrous, 2023; Yan, Kah, 2018) highlighting the potential for growth as more advanced benefits of BIM can be realized.

2.3.8 Benefits of BIM

Pre-Construction Phase

2.3.8.1 Enhanced Design Insight and Understanding

BIM allows designers to better understand design intent, resulting in design optimization without compromising client needs (Salleh, et al, 2023). It provides the ability to visualize and modify designs quickly, reducing errors and ensuring that design alternatives are evaluated efficiently (Sriyolja, Harwin, Yahya, 2021; Idris Othman et al., 2020).

2.3.8.2 Early Issue Detection and Improved Feasibility Analysis

BIM facilitates early detection of potential site issues, allowing project teams to make necessary adjustments before construction begins. This ensures better project feasibility and reduces the likelihood of costly design changes later in the project (Latiffi et al., 2016).

2.3.8.3 Improved Efficiency in Design Processes

BIM enables more efficient design reviews by simulating the model and improving accuracy in existing conditions documentation. This allows for sustainable design and better site analysis, leading to a more refined concept and feasibility evaluation (Kjartansdottir et al., 2017).

Construction Phase

2.3.8.4 Better Coordination and Communication

BIM enhances communication among project teams by allowing stakeholders to contextualize complex projects through interactive models (Salleh, et al, 2023). This fosters better collaboration and reduces miscommunications, ensuring a smoother construction process (Khosrowshahi, 2017).

2.3.8.5 Clash Detection and Reduced Design Errors

BIM minimizes rework by allowing early detection of design errors and constructability issues (Salleh, et al, 2023). This not only saves time and cost but also reduces material wastage, promoting more sustainable construction practices (Sriyolja, Harwin, Yahya, 2021). By automating construction management and coordination, BIM reduces the chances of errors or conflicting work, further streamlining the construction process (Idris Othman et al., 2020). For instance, in the Forest City project (Blocks C2 and C4), the main contractor, Giant Leaf, used BIM to identify 154 steel clash issues in 21,508 precast components before manufacturing, allowing the designer to quickly resolve them and avoid defects for 40 stories (Rui, Wah, Siang, 2021).

2.3.8.6 Automation of Quantities and Cost Estimation

BIM's ability to generate automated quantity take-offs (QTO) ensures that cost estimation is far more accurate than traditional manual methods (Sinenko, et al, 2020). This leads to more precise cost management throughout the project, reducing the potential for budget overruns (Khosrowshahi, 2017). Additionally, BIM's integration with 5D tools provides real-time cost updates as design changes are made, ensuring better control over financial resources during construction (Enshassi et al., 2018). For example, in the Forest City project, the contractor found excess material use due to site issues, prompting new management practices and training to ensure accurate material quantities, with BIM 5D strengthening cost management (Rui, Wah, Siang, 2021).

2.3.8.7 Improved Site Management and Scheduling

During the construction phase, 4D BIM (which integrates the time dimension) provides real-time visualization of construction sequences. This helps contractors to evaluate design feasibility and construction logistics, ensuring that the project is not only constructible but also efficient in its execution (Khosrowshahi, 2017). The accurate representation of construction activities and site conditions allows contractors to coordinate better, reduce site congestion, and improve health and safety (Deshpande & Whitman, 2014).

Post-Construction Phase

2.3.8.8 Enhanced Asset Management

BIM offers long-term benefits by providing clients with accurate, up-to-date asset data. This data is useful for facilities management, improving energy efficiency, scheduling maintenance, and maximizing the building’s lifetime value (Idris Othman et al., 2020).

2.3.8.9 Operational Efficiency and Reduced Maintenance Costs

BIM facilitates the management of building assets and equipment, ensuring that they are maintained per specifications. This helps clients reduce maintenance costs and enhance operational efficiency (Kjartansdottir et al., 2017).

2.3.8.10 Better Decision-Making through Lifecycle Data

BIM serves as a comprehensive tool that offers reliable, accessible information throughout the lifecycle of a building. This supports better decision-making regarding operations, maintenance, and repair activities (Khosrowshahi, 2017).

In summary, BIM offers significant advantages throughout all project phases, including design optimization, improved communication, accurate cost and quantity estimation, and long-term operational benefits for clients. These benefits make BIM a valuable tool for advancing efficiency, sustainability, and overall project quality.

2.4 Barriers hindering the process of BIM applications

While BIM offers advantages, integrating it into the architecture, engineering, and construction sector is tough and needs to overcome various obstacles for successful application in Malaysian construction industry. Therefore, this section concentrates on the barriers of using BIM. Upon application of BIM, several factors can be grouped into five main categories: technological, financial, policy, people, and process factors related to construction (refer Table 2.2).

2.4.1 Technological factor

Technological factors in construction projects involve technical issues, such as integrating BIM effectively. BIM naturally encourages the adoption of new technologies, but it is essential to first understand the existing technology landscape. This understanding helps in creating appropriate BIM models, managing the process effectively, and meeting the growing demands of the industry. Evaluation of BIM software technology typically considers factors like suitability, ease of use, compatibility, and interoperability (Chan, Sadeghifam, Joo., 2022).

2.4.1.1 Lack of interoperability between BIM software used by team members

The application of BIM faces significant obstacles due to the complex interchange of technological factors, particularly in terms of software compatibility and interoperability. This challenge is underscored by the need for different project teams to utilize the same BIM model, necessitating the transfer of data from their existing software to new BIM platforms (Ibtisam, Faizul, Nurshuhada., 2018). Limited interoperability between relevant BIM software further worsens these difficulties, resulting in ineffective collaboration and workflow (Memon, et al., 2014).

Moreover, the application of BIM faces challenges due to the complexities of data exchange systems. The fragmented nature of the construction industry leads to poor data quality and requires more time and effort for managing projects (Wong, Gray., 2019). Although supply chain management approaches have aimed to improve data flow, the industry's fragmented nature remains a barrier, preventing smooth integration. The use of different BIM tools by various parties introduces errors and limits collaboration, particularly in the early design stages (Chan, Sadeghifam, Joo., 2022).

While BIM is meant to simplify information exchange between software like AutoCAD and Revit, designers often struggle to integrate different tools when creating BIM models. This leads to compatibility issues when transferring data between old and new BIM platforms (Chan, Sadeghifam, & Joo, 2022). These challenges highlight the complex relationship between software compatibility, interoperability, and successful BIM application in construction. For example, Kamel and Memari (2019) investigated the interoperability between BIM and energy modeling tools, identifying key challenges like missing data, data recognition errors, and inconsistencies in file formats produced by GBS, OpenStudio, and EnergyPlus.

In short, the inability of different BIM software used by team members to communicate effectively is a major obstacle. When project teams use different tools, data transfer becomes inefficient, leading to errors and delays. This lack of interoperability hinders collaboration, particularly during the early design stages, where smooth coordination is crucial.

2.4.1.2 The complexity of the BIM model and building design

Inexperienced users may unintentionally alter data, creating risks for a project. The complexity of BIM software poses challenges for the local industry, leading to difficulties in managing design teams and contributing to project failures (Jamal et al., 2019). Similarly, Radman, et al., (2021) found that large-scale projects, often valued at over $1 billion, involve high complexity and take longer to reach substantial completion. These projects include multiple public and private stakeholders, are highly technical, and share critical attributes with multidisciplinary construction efforts, all of which contribute to delays when managing BIM complexity.

2.4.2 Financial factor

The organization's reluctance to adopt BIM is primarily due to the high cost of training employees. According to the Malaysia Productivity Corporation (MPC), many construction companies are hesitant to invest in new technologies and employee training because of uncertainty about future growth. The perceived costs of technology, training, and software are seen as major barriers to BIM application in construction firms (Roslan et al., 2019). As BIM is an advanced tool for collaboration in design, planning, and management, it understandably carries a significant expense.

2.4.2.1 High initial and training cost for application

Implementing BIM requires a significant upfront investment in upgrading software, hardware, and modifying workflows. In Malaysia, construction companies from Grade 1 to Grade 6 are hesitant to adopt BIM due to the high costs associated with software purchases and staff training (Ibtisam, Faizul, Nurshuhada, 2018). BIM technology is often seen as expensive, with substantial investments needed not only for acquiring the software but also for training and development. Many organizations struggle financially to provide adequate training, forcing them to rely on external experts, which further increases costs related to managing BIM data. Additionally, the costs of upgrading hardware and refining workflow processes deter many companies from adopting BIM (Ismail, Yousof, Adnan, 2021). For instance, a full BIM course from Autodesk can cost over $4,650 (BIM report, 2016), and a BIM manager in Malaysia can earn up to RM 6,294 per month (Tan et al., 2019). While BIM may be more economical for large-scale projects, the initial costs for simpler buildings can appear higher than traditional methods, making financial factors a major concern for companies considering BIM adoption. This perspective is supported by Ang et al. (2020), who note that the setup cost for a BIM project exceeds that of a conventional project, as BIM remains a new technology in the Malaysian construction industry. However, this setup cost is a one-time investment that can lead to significant long-term savings in large construction projects, ultimately increasing revenue. In contrast, while hiring BIM experts or consultants entails fixed, estimable costs, these expenses may not be justifiable for smaller projects where traditional methods may be more cost-effective.

2.4.2.2 ROI (Return on Investment) of using BIM not clearly defined

The organization's hesitation to adopt BIM is largely due to uncertainties about its return on investment (ROI). There is limited clarity on the cost savings BIM can provide, making it difficult to justify the significant upfront expenses (Paneru, et al., 2023). Additionally, there is no detailed report comparing the initial investment with long-term gains specific to the local context (Chan, Sadeghifam, Joo, 2022). As Malaysia's healthcare sector grows, integrating BIM with CBA becomes crucial for reducing design errors, improving quality, and ensuring cost-efficient project delivery, aligning with government infrastructure goals (Omar, et al., 2023).

2.4.3 Policy factor

The policy framework for BIM application in Malaysia currently lacks clarity regarding legal responsibilities and procedures. There is a need for established guidelines, standardized contracts, data ownership rights, insurance considerations, risk management structures, and clear role definitions for project participants (Chien, Wu, Huang, 2014). In Malaysia, BIM is being used to help reduce construction waste, particularly in key states like Pahang, Terengganu, Kuala Lumpur, Selangor, and Kelantan, which account for about 70% of the nation's waste (Rajendran, 2012). However, the government's initiative to implement BIM for waste reduction in western Malaysia, called "design-out-waste," faces challenges due to issues with contract documentation and legal disputes, making it harder to use BIM effectively for waste minimization.

2.4.3.1 Lack of government and professional bodies involvement

BIM adoption in Malaysia is primarily driven by organizations, as there are no government mandates for its full application in public or private construction projects, with entities like PAM, LAM, and PWD not enforcing regulations (Jamal et al., 2019). While the government promotes BIM and mandates its inclusion in agreements for government projects, leading to higher application rates in the public sector compared to the private sector (Othman et al., 2021), a lack of subsidies discourages top management from investing in essential training (Jamaludin et al., 2022). Government involvement is crucial, but without clear national strategies, effective enforcement remains challenging for authorities like PAM and LAM. To address these gaps, CIDB has made significant investments, such as allocating MYR 2.5 million to establish myBIMcentre, a training hub for industry stakeholders, and MYR 1 million from the CIDB Transformation Fund to incentivize construction firms to adopt BIM through training courses (Sinoh et al., 2020). Public-private partnerships and industry collaborations may also provide effective avenues for enhancing BIM adoption beyond reliance on government mandates.

2.4.3.2 Lack of industrial standard

The lack of a national BIM standard in Malaysia's construction industry presents a major challenge to BIM application. Without clear guidelines on BIM processes and procedures, companies often rely on their own standards or adapt those from other countries, which are typically tailored to specific projects rather than the industry as a whole. Furthermore, the absence of a standard contract for BIM projects, including defined responsibilities and dispute resolution procedures, creates confusion among project teams, especially when errors occur in the shared data model (Ibtisam, Faizul, Nurshuhada., 2018).

This lack of standardized contract documents also limits BIM's effectiveness as a collaborative tool, as there is no agreement on how to manage risks, resolve disputes, or integrate insurance. Additionally, the fragmented structure of the construction industry makes sharing BIM data with external teams, such as subcontractors, more challenging, increasing the risk of data exchange errors (Wong, Gray., 2019).

The absence of reference materials on BIM further slows the learning process for companies, as these resources could help guide their BIM adoption efforts. Without legal mandates requiring BIM on specific projects, its adoption remains limited. Moreover, unclear policies on BIM design models and the lack of standardized guidelines for risk assessments pose further barriers to effective BIM application (Chan, Sadeghifam, Joo, 2022). Similarly, Tam, Toam and Phong (2024) stated that the absence of industrial standards for BIM adoption can lead to inconsistencies in project execution, resulting in miscommunication and inefficiencies that negatively impact overall project outcomes. Additionally, the lack of standardized protocols can hinder collaboration among stakeholders, as varying practices may create barriers to effective data sharing and integration.

2.4.3.3 Intellectual property right (IP) and ownership of BIM model

The lack of clear legal provisions regarding intellectual property rights and data ownership creates significant obstacles to BIM application. Uncertainty about who owns and controls project data makes it harder to ensure smooth project progress, increasing risks (Ismail, Yousof, Adnan, 2021). Without formal contracts specifying data ownership, industry stakeholders are concerned about issues like copyright protection and data security (Wong, Gray, 2019). This legal gap, especially around ownership of BIM data, highlights the urgent need for legal safeguards and updated copyright laws. The situation is further complicated by designers' claims of ownership over BIM models. In addition, ongoing security issues and weak law enforcement in computer-based procurement systems add to the challenges (Toe, Sadeghifam, Joo, 2022). These overlapping issues emphasize the need for legal clarity to ensure the successful adoption of BIM in construction projects. For example, during the tender stages, companies view their proprietary information as a trade secret, as the realization of skills into ideas or proposals is crucial for securing contracts (Baharom, Habib and Ismail., 2021). To protect contributors' intellectual property rights, Section 3(b) of the Malaysia Copyright Act 1987 (Act 332) stipulates that their rights are safeguarded under the term "artistic work," which includes "a work of architecture being a building or a model for a building" (Laws of Malaysia, 2012, p. 11).

2.4.4 People factor

The move to BIM is not just about updating software and hardware; the socio-cultural environment plays a crucial role in its adoption. People are key to achieving success with BIM application. New circumstances must be accommodated for BIM to function effectively.

2.4.4.1 Resistance to change

Reluctance to change and adopt new workflows is a significant barrier to implementing BIM. This reluctance stems from human behaviour, as many in the architecture, engineering, and construction (AEC) field are comfortable with existing practices. Even when change lead to improvement, people resist it because learning new technologies like BIM requires skills that many organizations do not yet possess (Ismail, Yousof, Adnan, 2021). The adoption of new technology can create anxiety and feelings of threat among employees, who may fear that their roles will be replaced by the software and hardware required for BIM (Zainon et al., 2018). Additionally, some employees find BIM too complex and prefer faster completion using traditional tools (Toe, Sadeghifam, Joo., 2022). Similarly, Mustapa, Jamaluddin (2022) found that most construction professionals recognize BIM technology but are hesitant to adopt it due to uncertainties regarding its effectiveness in construction projects.

2.4.4.2 Lack of BIM education and training

The lack of proper training and a conservative leadership approach present major challenges for organizations adopting BIM. Many managers and leaders are not familiar with how to integrate BIM into their operations, leading to a shortage of skills and professionalism in the workplace, as BIM is often not adequately covered in tertiary education programs (Wong, Gray., 2019). Training staff to manage data and learn new software is also difficult, contributing to the construction sector's hesitation in adopting BIM. Additionally, without seminars, conferences, and workshops to raise awareness of BIM’s benefits, access to high-quality training from experienced professionals remains limited (Ariono, Wasesa, Dhewanto, 2022). As a result, organizations struggle with inexperienced users and face ongoing challenges in implementing BIM effectively (Toe, Sadeghifam, Joo., 2022). These interconnected issues highlight the critical role of training and education in successfully adopting BIM in the industry. CIDB and PWD offer comprehensive technical training for practitioners seeking to enhance their BIM knowledge and skills, focusing on software tools essential for effective BIM application. This training is tailored to specific professions such as architects, engineers, and quantity surveyors, and includes courses on Autodesk

Navisworks, Revit Architecture, ArchiCAD, and Revit, along with online resources on BIM concepts and application guidelines available on the CIDB official website (CIDB, 2020).

2.4.4.3 Lack of BIM benefit awareness

Stakeholder hesitation in adopting BIM arises from multiple challenges. Limited awareness of available software training and the time pressures in fast-paced construction projects create significant barriers. Additionally, the lack of accessible case studies demonstrating BIM's tangible benefits during the design phase reduces its perceived value (Chan, Sadeghifam, Joo, 2022). These issues are closely linked, as the lack of knowledge and proof of BIM's effectiveness contributes to stakeholders' reluctance to implement it. In Malaysia, a significant lack of awareness regarding the benefits of BIM persists, impacting its acceptance and integration within companies; as BIM becomes more utilized in daily operations, team engagement and understanding naturally increase (Manzoor, et al, 2021). To enhance awareness of sustainability's importance in the construction industry, professional bodies must actively organize workshops, lectures, and conferences focused on the role of BIM in promoting sustainable building practices, addressing the growing demand for environmentally sustainable construction in developing countries. For example, CIDB (2019) found that 74% of the respondents are aware of BIM, which is an increase from 45% in 2016, indicating that targeted awareness efforts can lead to significant improvements in understanding and acceptance of BIM technology.

2.4.4.4 Lack of BIM skilled workers

A major barrier to implementing BIM in organizations is the lack of skilled professionals capable of using it effectively, often due to resistance related to the "human factor" (Roslan et al., 2019). To overcome this challenge, organizations need to invest in improving the BIM skills and knowledge of their employees. The shortage of BIM professionals in projects worsens the situation, especially as the industry's limited interest in BIM leads to low demand for experts. Similarly, Wong, Rashidi and Arashpour, 2020 found that the Malaysian construction sector has experienced low productivity levels, primarily attributed to a significant reliance on low-skilled foreign labour in its workforce.

2.4.5 Process factor

Many organizations participate in the BIM process, employing different software options.

2.4.5.1 Lack of time to implement

Experts may find it difficult to learn new technology, which can take up a lot of their time. For beginners, getting used to the new workflow with BIM technology can be time-consuming, making them hesitant to try new processes. In fast-paced projects, there is not much time for experimenting with BIM, especially since it is still relatively new in the construction industry. Implementing BIM in these projects is tough because it requires time for learning, which could affect productivity and make companies unwilling to invest time in application. This view is supported by Naing, Sadeghifam, Joo (2022) who claims that the application of BIM requires a learning period, during which productivity may decline, making companies hesitant to allocate time for this transition.

Table 2.2: Summary of barriers hindering the process of BIM application

Barriers		**References**							
		Ibtisam, Faizul, Nurshuhada, 2018	Jamal, et al., 2019	Wong, Gray, 2019	Ibrahim, Rahman, 2019	Roslan, et al., 2019	Jamaludin, et al., 2022	Chan, Sadeghifam, Joo, 2022	Toe, Sadeghifam, Joo, 2022
Technological factor	Lack of interoperability between BIM software	√	√	√	√		√	√	√
	The complexity of the BIM model and building design	√	√	√	√	√	√	√	√

Barriers		References							
		Ibtisam, Faizul, Nurshuhada, 2018	Jamal, et al., 2019	Wong, Gray, 2019	Ibrahim, Rahman, 2019	Roslan, et al., 2019	Jamaludin, et al., 2022	Chan, Sadeghifam, Joo, 2022	Toe, Sadeghifam, Joo, 2022
Financial factor	High initial and training cost for application	√	√	√	√	√	√	√	√
	ROI (Return on Investment) of using BIM not clearly defined		√				√		

Barriers		References							
		Ibtisam, Faizul, Nurshuhada, 2018	Jamal, et al., 2019	Wong, Gray, 2019	Ibrahim, Rahman, 2019	Roslan, et al., 2019	Jamaludin, et al., 2022	Chan, Sadeghifam, Joo, 2022	Toe, Sadeghifam, Joo, 2022
Policy factor	Lack of government involvement	√	√	√	√		√	√	√
	Lack of industrial standard	√	√	√	√	√	√	√	√
	Intellectual property right (IP) and ownership of BIM model	√	√	√	√			√	√

Barrier		References							
		Ibtisam, Faizul, Nurshuhada, 2018	Jamal, et al., 2019	Wong, Gray, 2019	Ibrahim, Rahman, 2019	Roslan, et al., 2019	Jamaludin, et al., 2022	Chan, Sadeghifam, Joo, 2022	Toe, Sadeghifam, Joo, 2022
People factor	Resistance to change	√	√	√	√	√	√	√	√
	Lack of BIM education and training	√	√	√	√	√	√	√	√
	Lack of BIM benefit awareness				√	√	√	√	√
	Lack of BIM skilled workers	√	√		√		√		
Process factor	Lack of time to implement	√		√	√	√	√	√	√

2.5 Solution to increase the adoption of BIM

This section concentrates on the ways to increase the BIM adoption. These strategies can be grouped into two main categories: organisation-related and society-related strategies (refer Table 2.3).

2.5.1 Organisation-related strategies

Trust in BIM-based construction projects is built by the participating organization. Yet, due to the complexity of these projects, it is essential for professionals from different organizations to work together and integrate their efforts to complete project tasks. Key factors leading to this collaboration such as management, preparation, capability, cooperation, and awareness in the company (Farouk, et al., 2023).

2.5.1.1 Management

Aziz, Zainon (2022) emphasize the crucial role of top management in BIM application within organizations. Top management, or employers, should actively expand their knowledge to adapt to the evolving industry, initiating application from the top down to ensure employees keep pace with industry advancements. Zhan et al. (2022) recommend a top-down approach to enhance BIM adoption. The study emphasize that top management should allocate funds for software, infrastructure, and training, and set the direction for implementing BIM within the organization, which aligns with the findings of Sepasgozar et al. (2021). However, while top-down management involvement is crucial for setting the tone and direction of BIM application, it is essential to also emphasize the importance of bottom-up engagement. In many cases, frontline workers possess valuable insights and firsthand experiences that can inform the successful integration of BIM into daily workflows. By neglecting to involve employees at all levels of the organization in decision-making processes and training initiatives, there is a risk of encountering resistance or lack of buy-in, ultimately hindering the effectiveness of BIM adoption efforts. Therefore, a more comprehensive approach that incorporates input from all stakeholders, including frontline workers, can lead to more holistic and sustainable BIM application outcomes.

Building trust is key for successful BIM projects, and leaders need to be involved from the start. BIM helps construction run smoother by making tasks and planning easier. To gain buy-in from top bosses, a demonstration of BIM's functionality on real projects is necessary. This ensures everyone on the team understands the steps involved in using BIM, including deadlines and assigned responsibilities both internally and externally. For specific BIM challenges, the option of hiring an expert should be considered. Prior to commencing work, a BIM demo for everyone is crucial to ensure comprehension. While client presentations with project simulations can be helpful, maintaining client interest may not always be guaranteed (Farouk, et al., 2023).

2.5.1.2 Preparation

To build trust with BIM, everyone involved needs to be on the same page. This means training everyone on the project team, from architects and engineers to the client and the people who handle costs. Through learning about BIM, its capabilities will be revealed, fostering trust in its effectiveness. Everyone in the construction industry should also get familiar with BIM. Finally, a strong plan for using BIM should be created. This plan should include ideas from everyone on the team and be backed up by proof that BIM works, like success stories from other companies (Farouk, et al., 2023).

2.5.1.3 Capability

Getting the most out of BIM means making sure everyone on the construction site knows how to use it. This includes the supervisors who need to understand the BIM model well enough to find any differences between it and the old-fashioned 2D drawings. Also, everyone working on the project should understand why BIM is helpful and how it can make things go smoother in the long run. Even the bosses need to keep learning about new construction technologies, since BIM is always getting better. However, it is important to note that the critical role of senior management in staying updated on advanced construction technologies, including BIM, should not be overlooked (Farouk, et al., 2023).

2.5.1.4 Cooperation/ collaboration development by training

Reducing conflicts in projects is vital for establishing trust among team members. As project complexity increases, weakened collaboration among site teams, technical staff, consultants, project managers, and other stakeholders becomes increasingly critical for mitigating conflicts. It is crucial for all members to work together harmoniously and familiarize themselves with project drawings to detect clashes early on. Additionally, organizations that have succeeded with BIM should share their successes to inspire others to adopt it (Munianday, Rahman and Esa, 2022).

Training is key to getting BIM up and running smoothly. Even though there is not much research on the best ways to train people on BIM, it is important to create a detailed plan that considers what everyone will need to learn and what resources will be available. Well-designed training courses can help people improve their skills and learn more about BIM concepts and technology. Training staff is crucial for the company to adopt BIM successfully. Management also needs to provide the right software and technology for BIM to work. Sinoh et al. (2020) found that more BIM training for new employees leads to better BIM managers who are experts in BIM software. Training staff on the software is essential to make them BIM experts, which can create more BIM managers and keep everyone's skills sharp. This creates a positive cycle where BIM managers get better, and more people are trained. In short, gaining widespread acceptance for a new concept like BIM requires ensuring a clear understanding and dispelling any misconceptions among all stakeholders. Zhan et al. (2022) also point out that training not only improves skills but also makes employees more confident using BIM. Companies should offer internal training programs to help staff become proficient in the software. Overall, comprehensive training and education are essential to meet user expectations and keep everyone committed to continuous learning.

2.5.1.5 Awareness

The more people know about BIM, the easier it is to use and trust. This awareness helps everyone involved overcome challenges and benefit from BIM. Inside a company, getting people familiar with BIM early on is key. This can also help build trust with clients by showing them how BIM can make things run smoother. Additionally, promptly and accurately disseminating all pertinent information to every department is vital. Effective communication among project teams with strong communication skills can prevent many issues from arising (Farouk, et al., 2023). For example, according to Sinoh, et al. (2020), CIDB has actively promoted BIM awareness through annual BIM Days during the International Construction Week, BIM roadshows across Malaysia, and social media campaigns such as "#letsBIM". CIDB also organized an Intervarsity BIM Marathon and established the myBIMcentre, allocating funds for BIM training courses to encourage adoption among construction firms, demonstrating their commitment to fostering BIM adoption in Malaysia. These initiatives underscore CIDB's multifaceted approach to promoting BIM, engaging both industry professionals and the younger generation while providing essential training and financial incentives for widespread adoption.

2.5.1.6 Technology

The use of technology and offering trial software can significantly improve BIM application, according to Memon (2014). One way to get more people using BIM is to let them try it out for free. This is similar to how companies offer demos of new software. To ensure a positive experience during a BIM trial period, it is important to prioritize user experience. This will increase the likelihood of continued BIM usage beyond the trial period. Companies frequently utilize free trials to allow potential customers to evaluate a product before committing to purchase (Tolvanen, 2020).

2.5.2 Society-related strategies

Building trust in BIM goes beyond companies and needs to involve the whole construction industry. This can be done by introducing BIM to people early on in their careers, helping them develop the necessary skills, and getting support from government officials.

2.5.2.1 Individual

Continuous improvement in behaviour, knowledge, skills, and BIM awareness is necessary for all BIM project participants. Continuous improvement helps prevent issues caused by individual actions, fostering trust when problems are minimized. Attending construction events featuring successful BIM application presentations can raise public awareness. There is some debate about forcing companies to use BIM through contracts or laws, however, BIM should be seen as a helpful tool, not a completely new construction method. BIM serves as a facilitator in the construction process (Farouk, et al., 2023). Also, employees should take initiative in self-learning, either through peer learning or online resources, to stay updated with advancements in the construction industry. It is essential for employees to demonstrate a willingness to learn new skills and regularly practice their abilities, possibly through pilot projects, to effectively utilize BIM (Sinoh, et al., 2020).

2.5.2.2 Education

Education is key to building trust in BIM. Instead of just educating current industry professionals, BIM should be introduced in universities and colleges. This way, future generations will be comfortable using BIM from the start. This ensures that future generations have a strong understanding of BIM and how to use it effectively. By including BIM in the curriculum from the first year of study, especially in civil engineering programs or quantity survey programs, skilled professionals can be trained domestically rather than relying on imports from other countries. For instance, workshop and conference events can be conducted to raise awareness of the students (Manzoor, et al, 2021).

To encourage greater BIM utilization in the construction industry, staff training, and education programs should be implemented. Schools and professional organizations emphasize the importance of BIM education for enhancing specialized learning and recruiting in the sector. Malaysian tertiary institutions should revise their built environment courses to incorporate BIM education, preparing graduates for future professions. For example, conducting more seminars, lectures, presentations, workshops, and speeches to raise students' awareness towards the benefits of BIM application. By integrating BIM lectures into curricula and offering specialized training courses, universities can help students understand and appreciate BIM technology.

Collaboration between universities and the government, along with partnerships with foreign firms already using BIM, can facilitate its adoption in Malaysia (Munianday, Rahman and Esa, 2022). According to Sinoh et al. (2020), the significance of instilling BIM competency in higher education students, enabling them to influence companies to adopt BIM or seamlessly integrate into BIM-utilizing firms upon graduation. Despite challenges like insufficient BIM training for academic staff and the need for resources, incorporating BIM into engineering curricula can address the demand for competent BIM-ready graduates. The debate between business-oriented and academic BIM underscores the importance of balancing teaching and research in BIM education, supported by studies suggesting that graduates with BIM skills enhance industry uptake and employability.

Education and coaching are key factors in increasing BIM adoption. While ensuring that everyone has the necessary technology and skills can be challenging, organizations can establish technical support groups to address issues and promote knowledge sharing among employees. This approach encourages a spirit of collaboration and data sharing within the organization, contributing to successful BIM application. It is similar to when computers aided design (CAD) first came into construction, people needed a lot of training. The findings of this study suggest that widespread BIM adoption might necessitate training initiatives similar to those implemented for CAD (Sinoh, et al., 2020).

2.5.2.3 Government

Policymakers play a vital role in supporting BIM application and building trust among project team members. Providing complimentary Building Information Modelling (BIM) training through educational programs or workshops can be a successful strategy to enhance awareness and comprehension among industry professionals and the general public. Additionally, policymakers can influence successful BIM adoption by providing financial incentives, such as subsidizing application costs, making BIM more appealing and feasible for organizations (Farouk, et al., 2023). Furthermore, the government can incentivize the adoption of BIM by offering tax exemptions to organizations utilizing this technology in construction projects, thereby encouraging its widespread usage (Aziz, Zainon, 2022; Ahmed et al., 2022). Free BIM training programs spearheaded by policymakers can offer a significant boost to awareness and adoption, although limitations may exist in addressing the diverse skill levels and specific needs of the industry. Additionally, challenges in maintaining quality might arise when compared to industry-driven initiatives. Thus, a more effective strategy might involve combining government efforts with industry partnerships and customized training solutions to tackle the complexities of BIM adoption comprehensively.

Government support is crucial for enabling BIM adoption (Ahmed et al., 2022). The government can help the construction industry use BIM more by showing them all the ways it can be used throughout a project, from start to finish. The enactment of laws protecting intellectual property and digital asset ownership within the BIM environment can also be pursued. Businesses and government agencies can work together to offer training opportunities, so companies can reduce launch expenses when getting started with BIM. By recognizing the benefits of BIM and subsidizing software expenses, the government can encourage participation in BIM projects, ultimately leading to increased adoption and participation in the construction industry (Munianday, Rahman and Esa, 2022).

Given the high price of BIM software, it is essential for the government to incentivize its use in both public and private projects. By offering subsidies and incentives, the government can make BIM more accessible and encourage its application. Clear policies and regulations can address pricing concerns, and the government can provide interactive packages to construction players interested in implementing BIM (Zaini, et al, 2020).

2.5.2.4 Provision of legislation of BIM usage/Standardization

In construction, different specialists work together on projects. This can be especially tricky with BIM because everyone has different skills. To make things go smoothly, everyone needs to follow the uniform guidelines. These rules would include things like how to do the work, how to name computer files, and how to set up properties in the BIM model. Following these rules will make it easier for everyone to work together on the project (Sepasgozar et al., 2021; Bayhan et al., 2021). Additionally, attention should be given to addressing legal aspects, such as contractual issues and cybersecurity concerns, to ensure seamless application of BIM (Farouk et al., 2023).

Legislation can be a powerful tool to get more companies in construction to use BIM. When the government gets involved, it creates a better environment for everyone to use BIM. This includes having clear and consistent laws, offering educational programs, and funding research to develop BIM even further. Proactive government support fosters a uniform environment for BIM adoption, as seen in countries like Finland, Norway, Denmark, and Singapore (Munianday, Rahman and Esa, 2022). In open economies like Hong Kong, government intervention as a regulator ensures BIM compliance among private sector contributors. For BIM to be widely used in construction, the government needs to be involved. This will help create a consistent environment where everyone can use BIM easily.

Table 2.3: Solution to increase the adoption of BIM

Solution		**Reference**							
		Jamaludin, et al, 2022	Zaini, et al, 2020	Zaini, et al, 2020.	Munianday, Rahman, Esa, 2022.	Farouk., et al, 2023	Sinoh, et al, 2020.	Aziz, Zainon, 2022	Manzoor, et al, 2021
Organisation	Management					√		√	
	Preparation					√			
	Capability					√			
	Cooperation / collaboration development by training	√	√	√	√	√	√	√	
	Awareness					√	√		√
	Technology	√	√		√				

Solution		Reference							
		Jamaludin, et al, 2022	Zaini, et al, 2020	Zaini, et al, 2020.	Munianday, Rahman, Esa, 2022.	Farouk., et al, 2023	Sinoh, et al, 2020.	Aziz, Zainon, 2022	Manzoor, et al, 2021
Society	Individual				√	√		√	
	Education		√		√	√	√		
	Government	√	√	√	√		√		
	Provision of legislation of BIM usage/ Standardization				√			√	

2.6 Conceptual Framework

Through research on existing literature review, there are 5 aspects of barriers and 2 aspects of solutions been identified as shown in Figure 2.1. It is assumed that the application and performance of BIM in Malaysian Construction Industry could be affected by the barriers hindering the process of BIM application and the solutions to increase adoption of BIM.

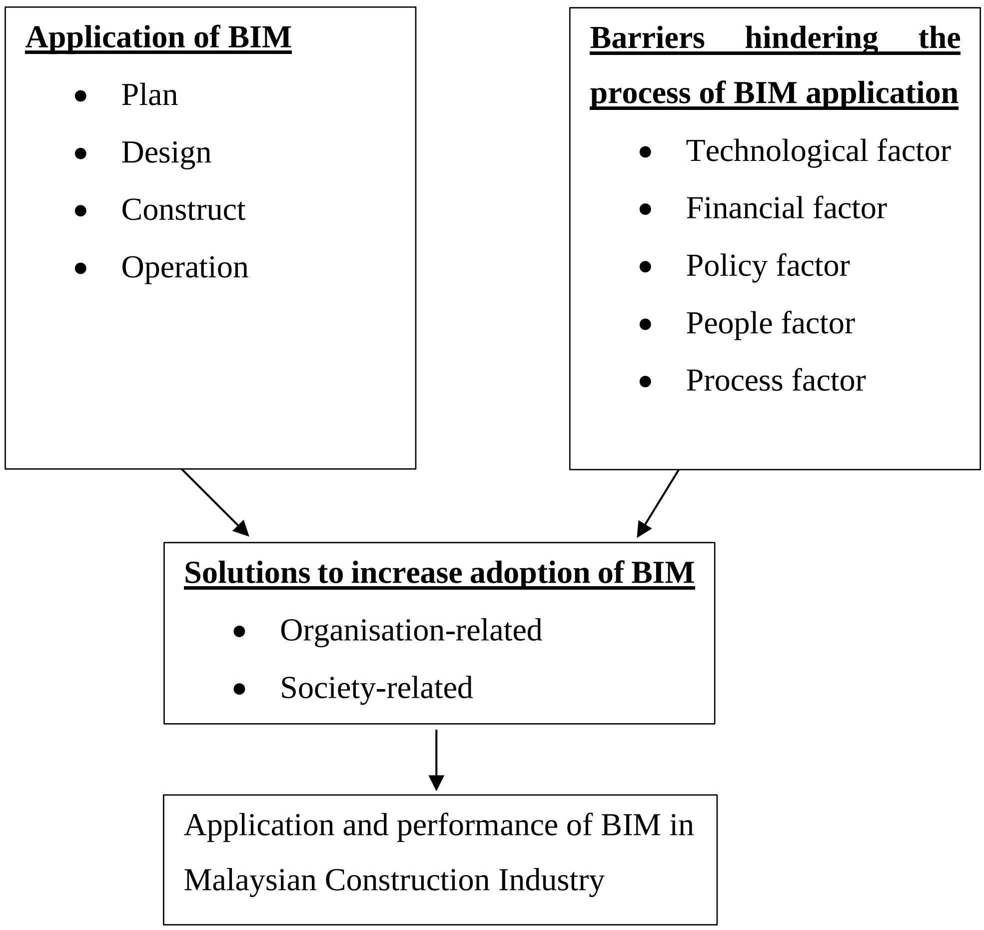

Figure 2.2: Conceptual Framework for application and performance of BIM in Malaysian Construction Industry

2.7 Summary

In short, this chapter summarizes about the challenges and solutions for using BIM in construction projects in Malaysia. The barriers of BIM application can be categorized into 5 main areas which are technological factor, financial factor, policy factor, people factor and also process factor. This chapter also includes current application of BIM which is one of the main focuses of this research.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

This chapter details the research methods employed in this study. Section 3.2 details the research method used. Section 3.3 will justify on the selection using mixed method research approach. Section 3.4 presents about the research design while Section 3.5 describes on the quantitative data collection. Section 3.6 is about qualitative data collection while Section 3.7 highlights the data analysis methods adopted such as Cronbach's Alpha Reliability Method, Thematic analysis, Descriptive Statistic, and Kruskal-Wallis H Test. Lastly, this section is ended by Section 3.8 summary of the chapter.

3.2 Research Methods

Research methods refer to the ways or approaches used to gather information or evidence for analysis. These methods help in discovering new knowledge or gaining a deeper understanding of a topic (The University of Newcastle,2023). Example on types of research method which are quantitative research approach, qualitative research approach and mixed method research approach.

3.3 Justification of Selection

This study is using one of the mixed method research approaches which is known as Concurrent Triangulation process. (Refer Figure 3.1). In mixed methods research, both quantitative and qualitative data are collected. Qualitative data will be analysed first and later follow by the quantitative data to validate and crosscheck the findings. As stated by Creswell (1999), this design is widely recognized. Equal importance is given to both methods, and the results from one method are checked and validated with the results from the other method to achieve a holistic view of the research inquiries. Ultimately, the data from both methods are interpreted together to draw meaningful conclusions (Creswell, 2004).

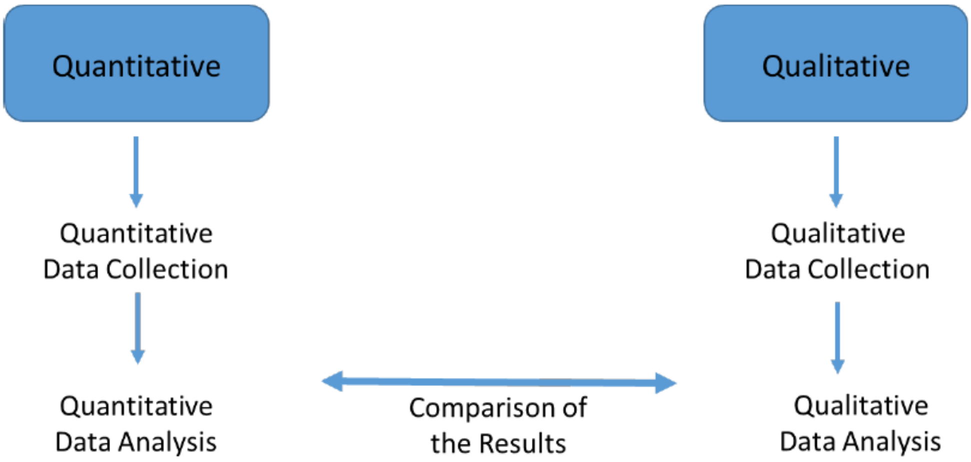

Figure 3.1: Concurrent Triangulation Process (Taherdoost, 2022).

3.3.1 In terms of Time

The Concurrent Triangulation process allows for gathering information from various sources and analyse it concurrently, which can save time compared to sequential methods. Given the research objectives to examine the current application of BIM and investigate barriers hindering its application, this method enables efficient data collection from multiple stakeholders within the Malaysian construction industry within a shorter timeframe.

3.3.2 In terms of Cost

By the combination of quantitative and qualitative data collection methods in a concurrent manner, the Concurrent Triangulation process can potentially reduce research costs. Traditional methods might require separate data collection efforts for quantitative and qualitative data, leading to increased expenses. With Concurrent Triangulation, this study can optimize resources and minimize costs while obtaining comprehensive insights into the adoption and performance of BIM in the Malaysian construction industry.

3.3.3 In terms of Title

The Concurrent Triangulation process aligns well with the research objectives of examining the current application of BIM, investigating barriers to application, and identifying solutions to increase adoption. For example, this method allows for the gathering of quantitative data on the current usage of BIM tools and technologies in Malaysian construction projects, as well as qualitative insights from industry stakeholders regarding challenges and potential solutions.

In short, by collecting both numbers and experiences (concurrent triangulation), this study can gather data for BIM application in Malaysia efficiently and affordably. This combined approach, using questionnaires and interviews, allows us to gain a complete understanding of the current application of BIM, the challenges companies face, and potential solutions to improve adoption.

3.4 Research Design

Research design refers to the approach used to carry out research within a specific methodological framework (Creswell, Creswell., 2023). Each design has its own procedures used in conducting research. The research design begins by outlining the scope, focusing on exploring BIM application and performance in the Malaysian construction industry. The research aims to investigate three main objectives: 1) the current application of BIM, 2) barriers hindering BIM application, and 3) solutions to increase BIM adoption. To achieve these objectives, a mixed method research approach is adopted, targeting professionals in the Malaysian construction industry as participants. The research methodology involves conducting a literature review to understand the current state of BIM application, identifying barriers, and exploring potential solutions. Subsequently, questionnaire surveys and interviews are utilized to gather insights from industry professionals. Quantitative data analysis is performed by sampling determination, while qualitative data from interviews are analysed through thematic analysis. Finally, the findings are summarized to draw conclusions and provide recommendations for enhancing BIM application and performance in the Malaysian construction industry. Figure 3.2 shows the Research Design Flow of this study. A pilot test will be conducted to assess the acceptability of the questionnaire before launching the full-scale study.

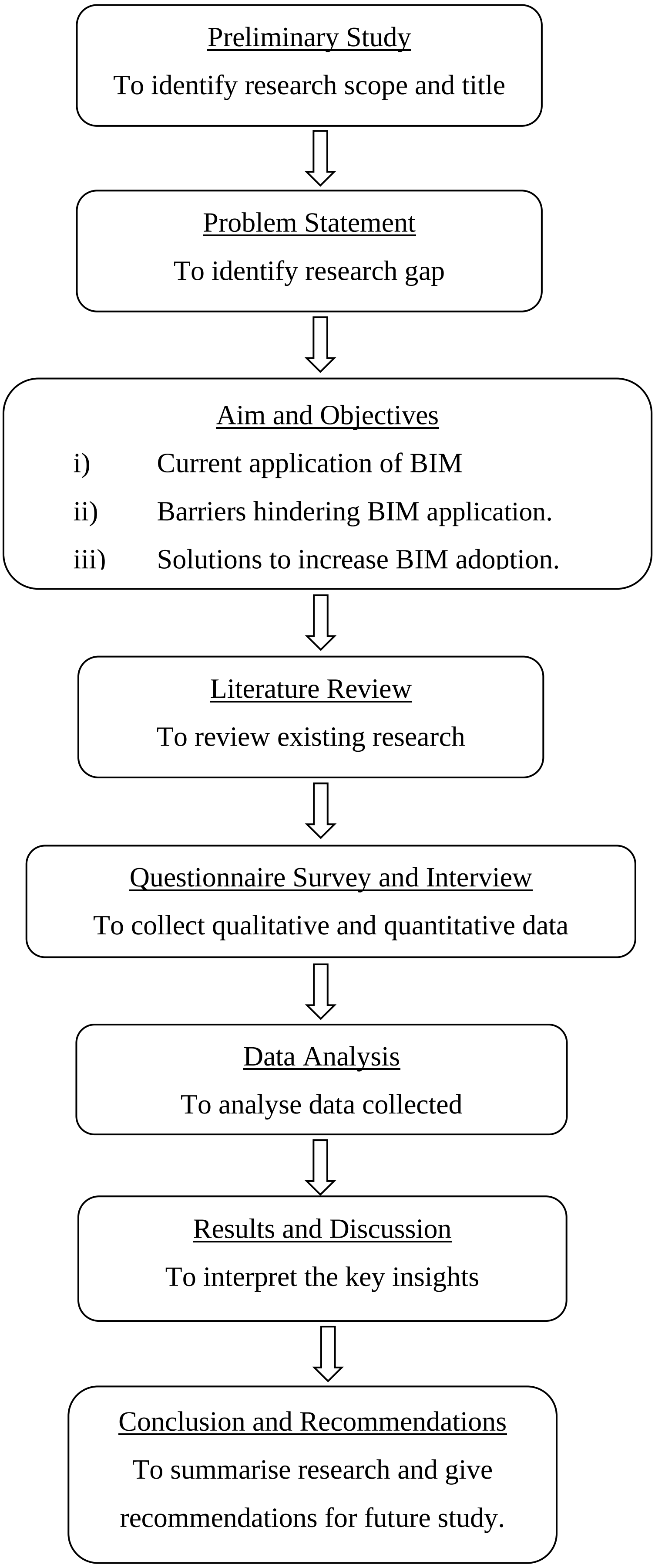

Figure 3.2: Research Design Flow

3.5 Quantitative Data Collection

This study employed quantitative data collection methods to assess the current level of BIM adoption within the Malaysian construction industry. An online survey tools, such as Google Forms, was used to administer a questionnaire to industry practitioners, gathering factual data on their BIM use. The design and structure of the questionnaire will be elaborated upon in detail within subsequent sections.

3.5.1 Questionnaire Design

The questionnaire for this research was structured into four main sections to gather relevant information aligned with the research objectives. Section A is Demographic Data Collection. This section gathered basic information about the respondents, such as their job title, years of experience in construction, highest academic qualification, and company size. These details would provide valuable insights into the characteristics of the respondents, which could help in understanding their perspectives on BIM adoption and performance.

Section B is Perception of BIM Adoption. Section B focused on assessing the respondents' current adoption levels of BIM in construction projects. Section C is about Barriers hindering BIM adoption. This section aimed to identify key challenges that need to be addressed to increase the BIM adoption in the Malaysian construction industry. Section D is Solution to increase BIM Adoption. This final section focused on solution to increase the adoption of BIM, in Malaysia Construction Industry. Respondents were asked to rate their opinions using a five-point Likert scale for Section B, C, D (refer table 3.2).

Table 3.1: Summary of Questionnaire Design

Section	Types of Question	Purpose
A	Closed-ended	To collect demographic information of respondents
B	5-points Likert scale	To achieve Objective 1: Current application of BIM
C	5-points Likert scale	To achieve Objective 2: Barriers of BIM adoption
D	5-points Likert scale	To achieve Objective 3: Solutions to increase adoption of BIM

3.5.2 Sampling Determination for Quantitative Data Collection

For the quantitative aspect of this study, the Cochran Formula (Cochran, 1977) was used to calculate the required sample size when the population size and proportion are unknown. It ensures that the sample size is statistically significant, using a 95% confidence level (z = 1.96) and a 5% margin of error (e = 0.05), resulting in a recommended sample size of 384.16 (Cochran, 1977; Uakarn, Chaokromthong, Sintao, 2021).

Sampling refers to selecting specific individuals or sources of information from which to gather data for the research (Isaac, 2023). In this study, the sampling was designed to target construction professionals such as architects, quantity surveyors, and engineers who are existing or current BIM users. These individuals were chosen for their high level of involvement in BIM practices, as their expertise and practical experience offer valuable insights into the current state of BIM application.

Also, the sampling strategy was carefully designed to ensure that the respondents, prominent construction practitioners in the Klang Valley accurately represent the larger population of BIM users in the construction industry. The selection process specifically targeted individuals who have previously used or are currently using BIM, as their expertise and practical experience provide crucial insights into BIM application. A total of 280 questionnaires were distributed, and 180 responses were received. After careful screening, 161 respondents met the criteria and were included in the study. Although this is lower than the original target, it is sufficient when supplemented by qualitative data collection, which adds valuable depth and context to the findings.

Cochran's formula was selected because it offers a reliable approach to determining an appropriate sample size when dealing with large or unknown populations. It ensures that the sample is statistically representative of the broader population while remaining practical for data collection purposes. The sample of BIM users, drawn from both private and public sectors, ensures that the data collected is reflective of industry practices. By combining the quantitative data from 161 respondents with qualitative interviews, the study achieves a comprehensive analysis of BIM adoption in the construction industry.

Formula for calculating sample size,

$$n = \frac{z^2}{4e^2} \qquad n = \frac{1.96^2}{4(0.05)^2} = 384.16$$

Where n=sample size

p=the population proportion

e= acceptable sampling error (e=0.05)

z= z value at reliability level or significance level

Reliability level 95% or significance level 0.05; z=1.96

3.5.3 Questionnaire Distribution

The questionnaire was prepared via "Google Forms" and distributed online to the respondents. The Google Form links were sent to the targeted participants via platforms such as Linkedin, Facebook pages, Whatsapp groups, Email, Microsoft teams and others. This study allocated a total of six weeks for distributing the questionnaires and collecting data from the participants.

3.6 Qualitative Data Collection

3.6.1 Interview Design

This study employed a semi-structured interview approach to gather in-depth data from respondents. The questions asked during the interviews will be based on the subthemes identified. As semi-structured interviews allow for flexibility, the questions may vary slightly from the interview guidelines. The structure of the interview themes and subthemes is designed to align with the study’s objectives of exploring the current application of BIM, identifying barriers hindering its adoption, and proposing solutions to increase its usage. The three main themes which are BIM Perception, BIM Practices, and Future Plans cover the respondents' personal views, experiences, and insights. Subthemes under each category address key aspects such as BIM software applications, challenges, solutions and future trends ensures that the data collected is comprehensive and directly supports the study's focus. Table 3.2 below provides an overview of the themes that will be addressed during the interviews.

Table 3.2: Theme & subtheme

Category	**Theme**	**Sub-theme**
A	BIM Perception	1: Personal View on current state of BIM adoption
		2: Key features of BIM Software
B	BIM Practices	1: BIM Software used
		2: Company current application of BIM
		3: Current/Previous BIM Projects involved
		4: Challenges hindering wider application of BIM
		5: Solutions to increase BIM adoption
C	Future Plans	1: Key trends that shape future of BIM in next 5-10 years
		2: Further plan of BIM adoption
		3: Will BIM become a norm in future?

3.6.2 Sampling Determination for Qualitative Data Collection

The research employed a semi-structured interview approach, chosen for its flexibility and focus on gathering detailed insights from individuals with relevant experience. This format allows the interviewer to ask pre-determined questions while giving interviewees the freedom to share their personal experiences. Interviewees were selected through purposive sampling, where participants were identified based on their expertise and experience in BIM application. This method was effective as it allowed the research to quickly access professionals with the necessary knowledge without requiring strict selection criteria. Potential candidates were screened through personal network and LinkedIn, targeting current and existing BIM users in the Malaysian construction industry from both the private and public sectors.

Initially, 15 candidates were selected, and invitations to participate in the study were sent out. However, 9 professionals (labelled R1 to R9) responded and agreed to participate in the research which included two representatives from the public sector and seven from the private sector, ensuring a balanced perspective on BIM application. Public sector interviewees were a Senior Construction Engineer (Senior Assistant Director) and a Civil Engineer, providing insight into government-driven projects. The private sector interviewees included a Digital Engineering Lead (Director), two Assistant Architects, a Mechanical & Electrical Engineer, an Assistant Mechanical & Electrical Engineer, a Senior RIB CostX Consultant, and a BIM Coordinator. This diverse selection of professionals represents various roles in the construction industry, ensuring that the data collected reflects both public and private sector perspectives.

Each interview session lasted approximately 30 to 60 minutes, conducted primarily via Google Meet for convenience, with one session held face-to-face. Prior to the interviews, participants received a questionnaire outlining 14 open-ended questions (refer Appendix A), allowing them to prepare and provide meaningful insights during the session. All interviewees consented to being audio recorded, contributing to the accuracy of data collection. The sample size of nine interviewees aligns with Creswell’s (1998) recommendation of 5 to 25 interviews for phenomenological studies and Guest et al.'s (2006) guideline that 6 to 12 interviews are sufficient for qualitative research. In qualitative studies, the focus is on analytic generalization rather than statistical generalization, and this selection of diverse industry players ensures that the data collected is credible and representative of the industry's varying approaches to BIM (Kong, et al., 2020).

3.7 Data analysis

Data analysis involves using statistical methods to examine, understand, and model the collected data systematically. This study used quantitative data analysis methods with the help of Statistical Package for Social Sciences (SPSS) software. Various statistical methods were utilized to explore meaningful relationships between variables. These methods included Cronbach's Alpha for assessing questionnaire reliability, descriptive statistics to summarize the data, the Kruskal-Wallis H Test for non-parametric comparisons, and thematic analysis to identify recurring patterns within the qualitative interview data. These methods will be discussed in more detail in the following subsection.

3.7.1 Cronbach’s Alpha Reliability Method

The Cronbach's Alpha Reliability test examines how reliable a measurement tool is by comparing the degree of correlation among its items. It helps assess the consistency of a scale used to measure a specific construct (Refer table 3.4). The Cronbach's Alpha test was employed in this study to assess the internal consistency of the Likert scale questions used in Sections B, C, and D of the questionnaire. This test produces a coefficient between 0 and 1, with higher values indicating greater reliability of the instrument in measuring the intended constructs. In simpler terms, it helps ensure the questions within each section consistently measure the same underlying concept. Generally, a coefficient between 0.70 to 0.80 is considered fair, while a coefficient greater than 0.90 is deemed excellent.

Table 3.3: Cronbach’s Alpha Reliability Coefficient Range (Glen, 2023)

Cronbach’s Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

3.7.2 Descriptive Statistic

Statistics like frequency, percentage, mean rank, and mode are used to provide basic information about the variables in the dataset and to find connections with respondents' backgrounds. Descriptive statistics simplifies and presents data. It includes demographics such as respondents' professions and work experience shown through frequency distribution. For example, frequency distribution of respondents' professions like Architects: 25%, Engineers: 30%, Project Managers: 20%, Quantity Surveyors: 15%, Others: 10%. This descriptive statistic provides insight into the distribution of professionals participating in the study and helps to understand the representation of different roles within the Malaysian construction industry regarding BIM adoption and performance.

3.7.3 Kruskal-Wallis H Test

This study employed a statistical test called the Kruskal-Wallis H test to see if there were any significant differences in how different groups of people answered the survey. These groups were divided based on their job category (architect, contractor, etc.), job title, and work experience. The test is used to determine whether the observed differences are merely due to chance or are statistically significant, warranting further investigation If the test result has a p-value less than 0.05, it indicates that the differences are likely real, and this study can then focus on those specific variations. Afterwards, this study compared its findings to existing literature on BIM to see if it identified anything new or if the results support existing ideas.

3.7.4 Thematic analysis

In this study, thematic analysis was chosen as a qualitative research method due to its effectiveness in identifying recurring patterns and insights from interview data. This method allows for a structured approach to organizing and interpreting data, which is essential for uncovering key themes related to BIM adoption in Malaysia's construction sector. Examples of themes could include "Challenges in BIM application," with sub-themes like "Lack of Training" or "Technical Issues."

Following Braun and Clarke’s (2006) six-step approach, the analysis began with familiarization with the data, followed by generating initial codes, searching for themes, reviewing themes, defining and naming them, and ultimately producing the final report.

The interview process commenced by contacting potential participants through LinkedIn and personal networks, following an initial screening of their profiles. Upon expressing interest, participants received an email outlining the proposed interview questions, a Google Meet link, and a request for consent to record the session. A reminder was sent one day prior to the scheduled interview. All interviews were recorded, and transcripts were generated using Microsoft Clipchamp. Thematic analysis was conducted, beginning with familiarization with the data, followed by initial coding using Microsoft Word and Excel. Themes were identified, reviewed, and refined to ensure alignment with the study's objectives. The entire process, from participant outreach to the production of the final report, was completed over a nine-week period.

3.8 Summary of Chapter

This chapter outlined the research methodology, which employed both quantitative and qualitative approaches. Data collection primarily relied on a questionnaire survey and interviews. Convenience sampling was utilized to select respondents. Furthermore, this study identified several data analysis techniques such as Cronbach's Alpha, Thematic analysis, Descriptive Statistics, and Kruskal-Wallis H Test. The subsequent chapter, Chapter 4, will delve into the analysis and discussion of the results obtained from the questionnaire and interview stages of this research.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents a demographic overview of the respondents and outlines the mixed-method research methodology employed. The qualitative part analyses semi-structured interview transcripts, while the quantitative part interprets statistical data using SPSS.

4.2 Pre-test

A pilot test was conducted to pre-test the questionnaire and ensure its suitability for the actual survey. Six questionnaires were randomly distributed to existing and current BIM users, with all being completed and returned, yielding a 100% response rate. These pilot surveys, conducted from 23 June 2024 to 26 June 2024, were excluded from the final data analysis. Feedback from the pilot phase helped refine the questionnaire by addressing grammar errors and ensuring clarity for respondents. This process improved the quality of the final survey and ensured more accurate data collection.

4.3 Results of interview

4.3.1 Background of Interviewee

Nine respondents were successfully interviewed. The transcript sample of respondent 6 was provided in Appendix B. Their demographic information can be found in Table 4.1 and working experiences can be found in Figure 4.1 for better visualization.

Table 4.1: Interviewee attributes

Respondents (R)	Professions	Company background	Years in construction industry	Years of using BIM software
1	Digital Engineering	Private sector,	28	20

	Lead (Director)	Consultant firm		
2	Assistant Architect	Private sector, Consultant firm	2	1
3	Mechanical & Electrical Engineer	Private sector, Contractor firm	6	1.5
4	Senior Construction Engineer (Senior Assistant Director)	Public sector, Consultant firm	18	12
5	Assistant Architect	Private sector, Consultant firm	2.5	1.5
6	Assistant Mechanical & Electrical Engineer	Private sector, Contractor firm	17	2.5
7	Senior RIB CostX Consultant	Private sector, Consultant firm	14	7
8	BIM Coordinator	Private sector, Consultant firm	3	3

9	Civil Engineer	Public sector, Consultant firm	16	7

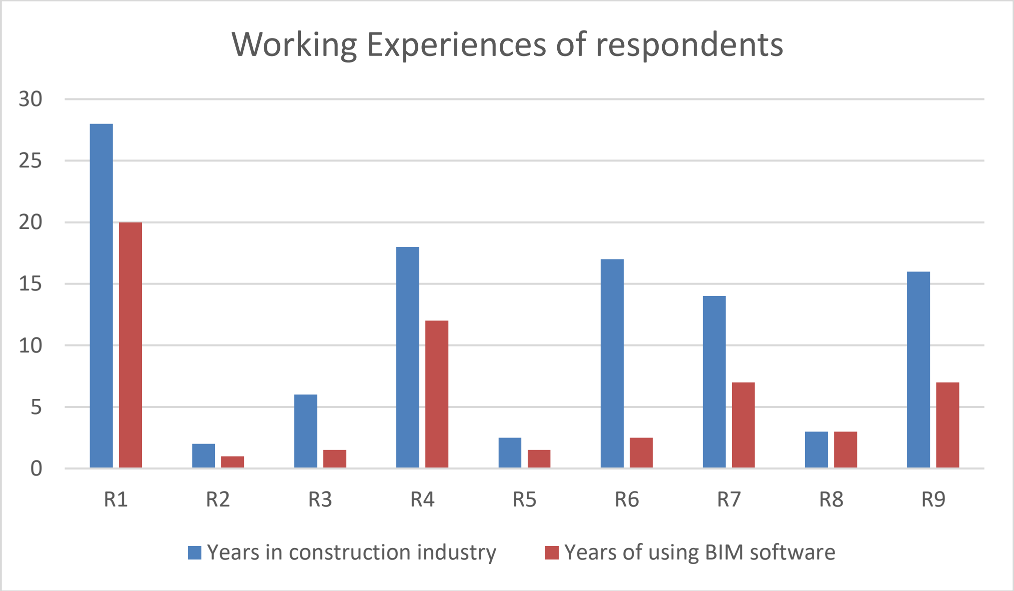

Figure 4.1: Working experiences of respondents

4.3.2 Personal View on current state of BIM adoption

Table 4.2: Data transcript for Personal View

Category A: BIM Perception Theme 1: Personal View on current state of BIM adoption	
Respondent	**Data Transcript**
R1	*"BIM has improved than they were five years ago in terms of people's understanding, and it will continue to grow."*
R2	*"BIM adoption is gradually gaining momentum, although with some challenges and opportunities."*
R3	*"... BIM has been progressively used, especially in the big mega projects."*
R4	*"So around right now from one project to 2010 and right now, I think more than almost 400 projects that we adopt BIM."*
R5	*"I think compared to five years ago, I think I've seen there's quite growth."*
R6	*"Nowadays, the awareness is increasing. More and more people get to know BIM software and they apply it."*
R7	*"I would say it is getting better in terms of adoption awareness."*
R8	*"Actually, for me I think is BIM grow quite fast in Malaysia. ... I start to hear about BIM is on 2019, and currently I can say most of the industry people they are using BIM and then they know BIM already."*
R9	*"The adoption of BIM in the Malaysian construction industry has been steadily increasing in recent years."*

4.3.2.1 Adoption of BIM in construction project

Respondent 4 mentioned that

"So around right now from one project to 2010 and right now, I think more than almost 400 projects that we adopt BIM."

According to Aris (2024), The Public Works Department integrated BIM into 455 projects from 2021 to 2024, covering various stages of planning, design, and construction.

4.3.2.2 Discussion

Government Initiatives

Respondents 1, 4, and 9 highlighted the role of government initiatives like JKR's mandate for BIM in projects valued over 10 million ringgits in promoting BIM adoption. The aim is to achieve 80% application by 2024 (Allison & Gerard, 2024; Afiq, 2020). However, Respondent 9 pointed out that while larger firms are leading these efforts, the industry still encounters significant obstacles, such as limited awareness, insufficient training, and a lack of investment in BIM technology.

Challenges for Smaller Firms

Respondent 8 mentioned that local clients and smaller firms often face difficulties in adopting BIM due to limited resources, awareness, and expertise (Zulkifli, et al., 2024). This issue is further worsened by a shortage of skilled personnel in smaller companies, hindering wider BIM application. Respondent 9 shared similar concerns, emphasizing the need for greater investment in training and awareness to bridge this gap.

Impact of Large Firms

Respondents 1 and 2 emphasized the growing adoption of BIM in Malaysia, with significant successes in large-scale projects like MRT2. Major firms such as Gamuda, Sunway Construction, YTL, and IJM are leading the way in BIM application (Ismail, Yousof, Adnan, 2021). Additionally, Respondent 1 noted that international companies investing in Malaysia, particularly in technology sectors like data centers and semiconductor plants, are raising BIM standards. While larger firms are leading this movement, there remains a need for further standardization and adoption across the industry, as highlighted by Respondents 1, 2, 5, 7, and 9.

4.3.3 Key Features of BIM Software

Table 4.3: Data Transcript for Key Features of BIM Software

Category A: BIM Perception	
Theme 2: Key Features of BIM Software	
Feature 1: Clash detection	
R2	*"Clash detection to prevent errors and delays."*
R3	*"Mention of identifying clashes through 3D visualization."*
R6	*"Early detection of errors through 3D modelling to reduce rework."*
R8	*"Clash detection coordination..."*
R9	*"Clash detection to identify conflicts between building systems."*
Feature 2: 3D modelling and visualisation	
R1	*"3D modelling for understanding design and construction sequencing."*
R3	*"3D visualization for identifying issues on-site."*
R9	*"3D visualization for better design understanding and decision-making."*
Feature 3: Cloud-based collaboration	
R5	*"Cloud collaboration to save time and improve collaboration."*
R9	*"Cloud-based solutions for better data accessibility and collaboration."*

*R= Respondent

4.3.3.1 Special highlight

Respondent 1 claimed that:

"Having a 3D representation of the project is still the most useful thing so that people are not relying on 2D drawings where it's not clear what some of the details are."

Respondent 1 highlights that the most valuable is actually the modelling and the industry still heavily relies on unclear 2D drawings, which can lead to misinterpretation and errors.

Respondent 7 highlighted that:

"Current Construction industry situation is Quantity Surveyors (QS) spend 70% of their time on quantity take-off, leaving only 30% for client advisement. However, the Ideal Situation of the time allocation should be reversed 70% on advising clients and 30% on quantity take-off. The solution is automating the quantity take-off process using software like RIB cost X or Glodon TAS/TRB, allowing QS to focus more on meaningful tasks like advising clients on costs."

Respondent 7 emphasizes the need for automation in quantity take-offs, explaining that current practices cause Quantity Surveyors (QS) to spend 70% of their time on manual calculations, reducing their ability to focus on higher-value activities such as advising clients. Automation tools, like RIB cost X or Glodon TAS/TRB, can help shift this balance, enabling QS professionals to dedicate more time to strategic planning and cost management, which improves project outcomes.

Respondent 8 stated that:

"Dynamo are valuable features, there's a lack of skilled personnel in Malaysia who can effectively utilize them."

Respondent 8 points out the lack of skilled personnel to use advanced tools like Dynamo, which hinders the full potential of BIM technology in Malaysia's construction industry.

4.3.3.2 Discussion

Key BIM features identified by respondents, such as clash detection, 3D modelling, and cloud-based collaboration, are transforming the construction industry. Clash detection helps prevent costly errors by identifying design conflicts before construction starts (Kermanshahi, et al., 2020). 3D modelling improves design clarity, reducing plan misinterpretation (Raza, et al., 2023).

Cloud-based collaboration enables real-time communication between project teams, enhancing coordination and decision-making (Progress, Said and Abbas, 2018). Despite these advantages, the full potential of BIM is not yet realized due to a significant skill gap. Respondent 8 highlighted a shortage of personnel skilled in advanced tools like Dynamo, which limits firms' ability to fully utilize BIM technology. To address this issue, targeted training programs, government initiatives, and partnerships with educational institutions are needed to develop the necessary expertise.

4.3.4 BIM Software used

Most respondents noted that Revit is their main BIM software because of its comprehensive design and modelling features. Respondents 1 and 4 highlighted Revit's dominance in producing models and drawings, while Respondents 6 and 7 mentioned its use for clash detection and structural integration. The widespread use of Revit shows its dominance in the industry, driven by both organizational efficiency and external factors like client needs and project complexity.

Tools like Tekla mainly for structural detailing, RIB Cost X for cost estimation and quantity take-off, and Civil 3D for civil engineering design are used during specific project phases to improve accuracy and efficiency. Additionally, Respondent 1 highlighted the use of Civil 3D and Infraworks for highway and railway projects, alongside Bentley software like Inroads and Inrails for some projects. With more projects moving to the cloud, Respondent 1 also noted the growing use of Autodesk Construction Cloud and BIM 360 for project management and collaboration.

Table 4.4: BIM software used

Category B: BIM Practice										
Theme 1: BIM software used										
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**Total**
Revit	/	/	/	/	/	/		/	/	8
Civil 3D	/									1
Bentley	/									1
Tekla				/				/	/	3
RIB Cost X				/			/			2
RIB 4.0							/			1
Autodesk Civil 3D									/	1

4.3.5 Company current application of BIM

Table 4.5: Summary of current application of BIM

Category B: BIM Practice									
Theme 2: Company current application of BIM									
BIM	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9 ***
Level 0									
Level 1		/	/			/			
Level 2	/			/				/	
Level 3									

- Level 0 – no collaboration, CAD, Level 1-3D modelling, Level 2 – Collaboration, Level 3 – Integration (Richard, 2014)
- *R9 depends on project type: it is moderate to high in infrastructure projects, high in building projects, emerging in maintenance and facility management, and low to moderate in smaller projects.

4.3.5.1 Discussion

Respondent's companies show different levels of BIM adoption, with most working at Level 1 (focused on 3D modelling) or Level 2 (using collaborative digital environments). Larger infrastructure and building projects, like MRT2, tend to use higher levels of BIM because of their complexity and size, which helps improve project management and coordination. In contrast, smaller projects often stay at Level 1, mainly due to limited budgets and hesitance to adopt new technologies. Companies still at Level 1 cite a lack of expertise and difficulty justifying the costs of fully adopting BIM, especially for simpler projects where traditional methods seem sufficient. Providing examples of companies successfully using higher levels of BIM could further show how these different adoption levels affect project outcomes, efficiency, and collaboration.

The difference in BIM adoption between project types is likely driven by the complexity and size of larger projects, which benefit more from BIM's collaborative features. Smaller projects, however, may not see BIM as essential because of tight budgets and the perceived high cost of software (Latiffi, Mohamad and Rakiman (2016). Additionally, the construction industry's ongoing reliance on traditional 2D drafting methods slows the shift to BIM. Respondent 8 pointed out that a major barrier is the lack of skilled workers, especially in smaller firms, emphasizing the need for more accessible BIM training and support to encourage wider adoption.

4.3.6 Current/Previous BIM projects involved

Table 4.6: Summary of BIM Project involved

Category B: BIM Practice	
Theme 3: Current/Previous BIM projects involved	
Interviewee	**Data Transcript**
R1	*“MRT3, bridge project”*
R2	*“Flat house”*
R3	*“High rise condominium”*
R4	*“National Institute of Putrajaya”*
R5	Not applicable
R6	Not applicable
R7	Not applicable
R8	*“Fresher project in Penang, semi-conductor factory.”*
R9	*“Hospital in Perak”*

4.3.6.1 Discussion

Respondents reported involvement in a range of BIM projects, from complex infrastructure developments like MRT3 to smaller-scale residential and commercial buildings. In projects like MRT3, BIM was essential for coordinating multiple stakeholders, managing complex designs, improving clash detection, and streamlining project timelines. For residential and commercial projects, such as the high-rise condominium mentioned by Respondent 3, BIM was primarily used to enhance visualization and design efficiency. In industrial settings, such as a semi-conductor factory in Penang, BIM facilitated precise coordination of mechanical, electrical, and plumbing (MEP) systems, reducing costly errors.

While larger projects leverage BIM to manage complexity and stakeholders, smaller projects often remain at BIM Level 1 due to limited budgets and reluctance to adopt new technologies. As Respondent 4 noted, BIM tools prevent clashes during construction, ensuring smoother project execution, avoiding costly variation orders (VOs) and increase quality of the project. Allison and Gerard (2024) emphasize that BIM's future applications could extend beyond buildings to infrastructure projects like sewage and roads, preventing construction issues and clashes. Though BIM may not always shorten timelines, it significantly reduces rework, ensures design accuracy, and improves overall quality across different project types. Smaller companies, however, still face challenges such as lack of internal expertise and justifying the costs of full BIM integration, particularly for projects where traditional methods are seen as sufficient.

Respondents 5, 6, and 7 reported no involvement in BIM projects, highlighting potential barriers to adoption within their organizations. These barriers may include budget limitations, a shortage of skilled staff, or resistance to adopting new technologies. Overcoming these challenges, particularly in smaller firms or less complex projects, is key to expanding BIM usage industry wide. Offering targeted training and improving access to BIM technology could help promote broader adoption and foster innovation in smaller-scale projects.

4.3.7 Challenges hindering wider application of BIM

Table 4.7: Coding Legend for Challenges

Category	Theme	Sub-theme	Code
B. BIM Practice	Technological	Interoperability	A1a
		Complexity	A1b
		Hardware and software	A1c
		Limitation of 3D model	A1d
		BIM integration with other technologies	A1e
	Financial	High initial and training cost	A2a*
		Rate of investment (ROI) not clearly defined	A2b
	Policy	Lack of government involvement	A3a
		Lack of industrial standard	A3b*
		Intellectual property and ownership of BIM	A3c
	People	Resistance to change	A4a*
		Lack of education/training	A4b
		Lack of BIM benefit awareness	A4c
		Lack of BIM skilled workers	A4d*
		Miscommunication	A4e
		Technological knowledge	A4f
		Ego of subcontractor	A4g
	Process	Lack of time to implement	A5a

Table 4.8: Coding Matrix of Challenges Determined by Respondents

Category B: BIM Practice										
Theme 4: Challenges hindering wider application of BIM										
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**Total Respondents**
A1a		/		/			/		/	4
A1b	/	/						/	/	4
A1c		/	/	/		/				4
A1d			/				/			2
A1e				/						1
A2a	/	/	/	/		/	/	/	/	*8
A2b	/						/	/	/	4
A3a				/					/	2
A3b	/			/	/	/	/	/	/	*7
A3c		/							/	2
A4a	/	/		/	/		/	/	/	*7
A4b	/			/		/			/	4
A4c	/	/		/		/			/	5
A4d	/	/	/	/		/	/	/	/	*8
A4e		/	/	/			/	/	/	6
A4f			/	/				/		3
A4g								/		1
A5a	/			/		/		/	/	5

Table 4.9: Coding Matrix of Challenges Expressed by Respondents

Summaries of Data Transcript	
Category B: BIM Practice	
Theme 4: Challenges hindering wider application of BIM	
A1a: Interoperability	
R2	*"Different disciplines often use different software platforms or versions, leading to interoperability issues when sharing BIM models or data, affecting data consistency and project timeline."*
R4	*"CIDB overcame software compatibility issues by standardizing on a single BIM platform, Navisworks, for design coordination and clash analysis, while integrating other software like Tekla with Revit through plugins, which required extensive R&D and vendor collaboration to ensure effective interoperability."*
R7	*"One of the limitations … is interoperability.* *Because at the moment there is no companies, there is no software that can covers everything. As different professions use different tools and prefer different modelling approaches, leading to conflicts and inefficiencies."*
R9	*"Challenges with interoperability between different BIM tools and software can complicate collaboration and information sharing, affecting the efficiency of BIM application."*
A1b: Complexity	
R1	*"Technical limitations such as file size, project complexity, and software compatibility present challenges in managing BIM."*
R2	*"One significant challenge I've encountered is the complexity of advanced features such as Revit links, family creation, legends, and key tags which require a structured understanding of how to effectively utilize them to enhance project workflows and documentation."*

R8	*"Clients often underestimate the complexity of BIM, mistakenly believing it to be a simple process, which reflects a broader resistance to embracing new technologies fully."*
R9	*"The complexity of BIM technology and its integration into existing workflows can be daunting for many in the construction industry, contributing to resistance to adoption."*
A1c: Hardware & software (supercomputer)	
R2	*"Current hardware limitations, such as the need for supercomputers to run advanced BIM software, hinder on-site usability."*
R3	*"BIM software requires high-end hardware for efficient visualization and processing. Standard laptops may experience lagging and slow performance. Additionally, the need for powerful computers limits BIM's practicality for on-site use."*
R4	*"Managing a large number of projects (400+ ongoing and 300+ in adoption) with limited software licenses across 500-600 designers is a major challenge. The team must strategically allocate software resources and optimize their usage, especially for complex projects like hospitals, which have intricate system requirements that necessitate careful coordination."*
R6	*"High-spec computers with advanced graphics capabilities are essential for running software like Revit and Navisworks smoothly, which not all PCs can support."*
A1d: Limitation of 3D model	
R3	*"Relying solely on BIM for 3D modelling can lead to delays and additional steps, such as needing to consult and update models repeatedly, which may be less straightforward compared to traditional methods."*
R7	*"BIM models often lack crucial details, such as excavation and formwork designs, requiring QSs to manually estimate*

		quantities, leading to incomplete or inaccurate cost estimations."
A1e: BIM Integration with others		
	R4	*"Integrating BIM with other tools like QS software (CostX) required customization and development of new processes, such as creating formulas that allow software to communicate effectively with Revit. This integration is essential for improving project cost management and design processes."*
A2a: High initial (license) and training cost		
	R1	*"The tight budget constraints across projects limit the ability to invest in new technology and training. "*
	R2	*"…initial cost of application. This includes expenses related to software licenses, hardware upgrades, and training for personnel."*
	R3	*"The high cost of BIM software, such as Revit, makes it more practical for mega projects, while smaller projects might find the cost prohibitive as we have a bigger budget for a project."*
	R4	*"The high cost of software licenses and the need for extensive training are significant barriers. Despite some past government incentives, current budgets are tight, making it difficult to secure funds for software purchases and training programs."*
	R6	*"The original software for the BIM costs much."*
	R7	*"Money is always the first one. We don't have money."*
	R8	*"Companies often underestimate the manpower and expertise required for effective BIM application, leading to misperceptions about costs, particularly in relation to staff training and the ongoing expenses of BIM tools and hardware. Only like those big scale company they will do this as they have extra money to do so, for small company they are struggling to get the profit."*

R9	*"The significant upfront costs for BIM software, hardware, and training deter many construction firms, particularly SMEs, from adopting the technology, despite its potential long-term benefits. "*
A2b: ROI not clearly defined	
R1	*"There's a lack of incentive to invest in innovative solutions because the return on investment is not clearly defined or guaranteed. The market prefers short-term savings over long-term gains."*
R7	*"Even in advanced countries, the full benefits of BIM are often not realized, with users typically achieving only 70-85% of potential ROI, highlighting the difficulty in fully utilizing BIM's capabilities."*
R8	*"The benefit of BIM can be difficult to quantify, especially when estimating rework costs before a project begins. In practice, the effectiveness of BIM is measured by identifying and resolving clashes during the development of LOD 300 models. While achieving zero clashes is unlikely, reducing the number of significant issues before construction can prevent costly rework."*
R9	*"Uncertainty around the return on investment for BIM, especially in a competitive industry with tight budgets, leads to hesitance in adopting the technology."*
A3a: Lack of government involvement	
R4	*"While there is some government involvement through past incentives for BIM adoption, the current lack of a dedicated digital budget or fund for BIM technology and training is a challenge. CIDB must find alternative ways to finance these needs."*
R9	*"The absence of strong government support and clear regulations in Malaysia slows down the adoption of BIM, as firms may lack the incentives and standards necessary to implement it effectively."*

A3b: Lack of industrial standard	
R1	*"The absence of standardized practices and guidelines in the industry hinders the widespread adoption of BIM and other technologies."*
R4	*"The need for industry standards is implied through CIDB's efforts to set up organizational information requirements and strategize technology adoption."*
R5	*"The absence of standardized BIM requirements in Malaysia's construction industry leads to inconsistent software usage, with many firms still relying on older tools like SketchUp and AutoCAD, resulting in inefficiencies and slower adoption of BIM technology."*
R6	*"The absence of clear guidelines and standards for BIM application creates uncertainty, with usage depending heavily on individual client preferences."*
R7	*"The existence of multiple, competing BIM standards (ISO, CIDB, RICS) without a unified approach leads to confusion and inconsistency, with each standard-bearer claiming superiority, complicating application."*
R8	*"The existence of multiple BIM standards and frameworks without a universally accepted standard creates confusion and fragmentation in the industry."*
R9	*"The lack of standardized processes and protocols for BIM across the construction industry exacerbates difficulties in integrating BIM, leading to inefficiencies and misalignment in project goals."*
A3c: Intellectual property & ownership of BIM	
R2	*"In some cases, contractual agreements or legal frameworks may not fully accommodate BIM processes, such as liability for model accuracy or intellectual property rights related to BIM data."*
R9	*"Fragmentation in the construction industry and the reluctance of some stakeholders to fully adopt BIM due to*

	concerns about transparency and data security impede collaborative efforts and hinder BIM's broader application."
A4a: Resistant to change	
R1	*"It's fundamentally a financial constraint and it's fundamentally the way the market is structured in Malaysia. It's very difficult in a very tight market to increase the innovation levels."*
R2	*"There remains a level of resistance to change among stakeholders who are accustomed to traditional construction methods."*
R4	*"There is significant resistance to adopting BIM among stakeholders, especially those used to work in 2D. "*
R5	*"AutoCAD's long-standing presence in the industry has created a comfort zone for many professionals. This familiarity discourages them from investing time and resources into learning new software like BIM. The reluctance to upskill and adapt to new tools is a significant barrier to BIM adoption, as individuals prefer sticking to what they know, perceiving it as easier and less time-consuming."*
R7	*"Older generations in the construction industry are particularly resistant to adopting new technologies like BIM, preferring traditional methods and creating a significant barrier to wider BIM adoption."*
R8	*"Clients and industry professionals often misunderstand the complexity of BIM, leading to resistance to adopting the technology fully, especially among those with limited exposure to it."*
R9	*"Resistance from subcontractors, who may prioritize their traditional methods over collaborative BIM processes, can hinder the effective integration of BIM on construction projects."*

A4b: Lack of education/training	
R1	*"The reluctance of companies to invest in training due to fears of losing employees, coupled with the industry's heavy reliance on skilled individuals, creates a significant barrier to effectively educating and training workers to manage and utilize BIM."*
R4	*"The ongoing education and training are needed especially given the lack of BIM awareness among clients and some contractors. CIDB conducts roadshows and engagement sessions to promote BIM adoption, but the challenge remains due to limited budgets."*
R6	*"Many subcontractors lack basic BIM training, requiring companies to conduct short classes on-site to familiarize them with the software."*
R9	*"The shortage of BIM-trained professionals in Malaysia, coupled with insufficient educational programs and resistance from those accustomed to traditional methods, hinders the successful adoption of BIM."*
A4c: Lack of BIM benefit awareness (stakeholder)	
R1	*"There is insufficient awareness among stakeholders about the benefits of BIM…"*
R2	*"Limited understanding of BIM's benefits among stakeholders leads to resistance and misunderstandings about adopting BIM workflows."*
R4	*"Many clients and stakeholders do not fully understand the benefits of BIM, focusing instead on traditional concerns like tender timelines. CIDB works to educate them on the long-term benefits of BIM, such as cost savings and improved project coordination."*
R6	*"Subcontractors often have low awareness of BIM's advantages, such as 3D modelling and crash detection, which hinders its effective application ."*

R9	*"Many stakeholders remain unaware of the full benefits of BIM, which limits its adoption and hinders the realization of its potential efficiencies."*
A4d: Lack of BIM skilled workers	
R1	*"There is a shortage of trained BIM professional. Finding enough skilled professionals to build accurate models and manage BIM processes efficiently is a significant issue."*
R2	*"Another significant challenge is the shortage of skilled professionals proficient in BIM software and methodologies."*
R3	*"Implementing BIM requires hiring skilled Revit modelers and engineers who need specialized training. There is a significant training challenge for staff to become proficient in 3D modelling."*
R4	*"There is an ongoing need to develop a skilled workforce capable of effectively using BIM. CIDB's efforts to train staff and engage with contractors and consultants indicate a recognition of this gap."*
R6	*"A significant challenge is the lack of BIM-experienced personnel, especially among subcontractors, leading to difficulties in communication and proper usage of BIM."*
R7	*"There is a shortage of BIM expertise in Malaysia, exacerbated by skilled professionals leaving the country for better opportunities abroad."*
R8	*"Despite universities introducing BIM in their curricula, there remains a shortage of skilled BIM professionals in the industry, leading to high demand and competitive salaries for those with expertise."*
R9	*"The shortage of BIM-trained professionals in Malaysia, coupled with insufficient educational programs and resistance from those accustomed to traditional methods, hinders the successful adoption of BIM."*

A4e: Miscommunication

R2	*"Poor communication and coordination among project stakeholders can cause errors and rework due to delays and miscommunication."*
R3	*"Effective communication is crucial, as failure to properly communicate BIM-related information among engineers, clients, and architects can lead to significant issues."*
R4	*"Miscommunication between software tools and project teams is a recurring issue that the agency addresses through R&D and process standardization, particularly in the integration of different software platforms."*
R7	*"There is frequent misalignment between designers and QSs in interpreting 3D models, often leading to rework or dual referencing systems to accommodate different interpretations of the same model."*
R8	*"The gap between BIM model expectations and on-site construction practices can lead to significant miscommunication, particularly when design elements are not feasible in practice."*
R9	*"Communication barriers, including misalignment of goals and fragmented communication among stakeholders, can lead to delays and inefficiencies in BIM projects, undermining collaboration."*

A4f: Technological knowledge

R3	*"Some people, it's hard to catch up with this new revolution of 3D model."*
R4	*"The agency needs to constantly update its technological knowledge, especially when integrating new software tools. This involves engaging with vendors and conducting R&D to solve integration challenges."*
R8	*"BIM personnel may lack practical construction knowledge, leading to designs that are not feasible or practical on-site,*

	causing disconnects between the model and real-world application."
A4g: Ego of subcontractor	
R8	*"Subcontractors may resist adapting to BIM processes due to personal biases or ego, which can hinder effective collaboration and application of BIM across project teams."*
A5a: Lack of time to implement	
R1	*"Time constraints in projects also impact the ability to implement and manage BIM effectively."*
R4	*"Implementing BIM and achieving effective coordination is time-consuming, often leading to delays in project timelines. This is particularly true for complex projects where detailed design coordination is essential but time-consuming."*
R6	*"Time constraints make it difficult to properly implement BIM, especially for subcontractors with no prior experience."*
R8	*"Time constraints within projects often limit the thorough application of BIM, as stakeholders might rush processes or bypass essential BIM integration steps."*
R9	*"The time required to effectively implement BIM, including training and workflow adjustments, can be a significant barrier, especially for projects with tight schedules."*

4.3.7.1 Special findings

For A4a- Resistant to change, Respondent 8 elaborated that:

"The challenges faced when initially implementing BIM, such as time constraints and subcontractors' resistance due to their reliance on traditional methods. Early on, there was no buffer for BIM processes like clash detection, leading to site issues and dissatisfaction from clients and contractors. Subcontractors, accustomed to working from 2D drawings, were initially reluctant to adopt BIM, arguing that their years of experience made it unnecessary. However, through persistent communication, on-site

collaboration, and demonstrating the benefits, subcontractors eventually realized that BIM helped save time, reduced rework, and improved efficiency." This experience highlights the importance of industry-wide efforts to embrace BIM and the need for education, patience, and collaboration to overcome resistance to new technologies.

Respondent 1 have the same idea that:
"It's very difficult then to bring in new technology, new skills, new software, new people and train up those people."
Introducing new technology and skills is hard because it requires time, training, and resources, which can disrupt current operations (Akmal, Nazareth, Hamimah, 2021). Additionally, external pressures, like regulations or competition, make it more challenging to adapt quickly.

Respondent 8 further suggests that:
"Broader adoption requires a shift in mindset, as the benefits of BIM become clear only when everyone is willing to engage with the process."
Support from the government or industry could help push more people to embrace the technology despite cultural resistance and cost concern.

For A2b- ROI not clearly defined, Respondent 8 noted that:
"*The benefit of BIM can be difficult to quantify, especially when estimating rework costs before a project begins. In practice, the effectiveness of BIM is measured by identifying and resolving clashes during the development of LOD 300 models. While achieving zero clashes is unlikely, reducing the number of significant issues before construction can prevent costly rework."*
This approach highlights how addressing major clashes early on can lead to substantial cost savings, especially in large projects where rework expenses can reach five to six figures (R8). The reason behind this method is that resolving design conflicts beforehand minimizes disruptions and avoids delays during construction.

4.3.7.2 Discussion

The first major barriers hindering BIM adoption in the Malaysian construction industry mentioned by eight respondents are the high initial costs (A2a). The high initial cost of software licenses, hardware, and training present significant barriers to BIM adoption (Sharen, 2024; Ahmed et al., 2022). Many respondents highlighted budget constraints as a primary factor limiting investment in new technology and training programs, especially in the case of smaller companies (R1, R4). Larger companies especially those handling mega projects, can justify the substantial cost of BIM. However, smaller firms and SMEs face considerable challenges to afford these expenses, making it hard for them to adopt BIM (R3, R8, R9). This cost includes not only software like Revit but also the necessary hardware upgrades and extensive training needed to fully leverage BIM's capabilities (R2, R8). Despite the long-term benefits, many companies, particularly SMEs, are discouraged by these upfront costs (R7). Although government has introduced incentives in the past, these measures have been insufficient in offsetting significant financial burden, making it difficult for firms to secure the necessary funding for BIM adoption (R4). The high upfront costs highlight a broader issue within the construction industry, particularly SMEs, often operates on tight margins. This makes it harder to justify large investments without immediate returns. Additionally, the lack of sufficient government incentives or subsidies highlights a gap in policy support, which is needed to make advanced technologies like BIM more accessible across all company sizes.

The second major barrier is the shortage of skilled BIM professionals (A4d), as noted by eight respondents highlighting the lack of expertise required to build accurate models and manage BIM processes efficiently (R1, R2, R3; Ariono, Wasesa, Dhewanto, 2022). Although universities have begun offering BIM training, the construction industry still faces a significant talent gap. This shortage drives up both the demand and salaries for BIM skilled professionals (R8, R9). Small firms struggle to attract skilled BIM professionals due to limited budgets and inability to compete with larger organisation (R8). The shortage of skilled subcontractors also hinders effective BIM usage on-site (R6). Furthermore, the talent shortage is worsened by the migration of BIM-trained professionals seeking better opportunities abroad (R7). CIDB’s efforts to bridge this gap through training initiatives are recognized, but broader industry-wide efforts are necessary (R4). The shortage of skilled BIM professionals is caused by rapid BIM adoption exceeding available training and a lack of sufficient talent produced by universities. Smaller firms also struggle to compete with higher-paying jobs abroad, making the local talent gap a significant barrier to wider BIM adoption.

The third barrier mentioned by seven interviewee is the lack of industrial standards within the industry (A3b). Without clear industrial standards, firms often use software inconsistently, resulting in inefficiencies across projects (R1, R5). Without clear guidelines, BIM application varies widely depending on client preferences, creating uncertainty (R6). Competing standards, such as ISO, CIDB, and RICS, further complicate matters, making it challenging for firms to adopt a unified approach to BIM application (R7, R8). This fragmentation in standards leads to misalignment in project goals and slows down the integration of BIM into everyday workflows (R9). CIDB’s efforts to establish organizational requirements and promote standardization are steps in the right direction but need wider industry adoption to have a meaningful impact (R4). The absence of clear industry standards creates confusion and slows BIM adoption, as companies struggle to follow different guidelines. Without stronger government support or industry collaboration, initiatives like CIDB's will remain limited in impact (Sharen, 2024).

The resistance to change (A4a) is another significant barrier to BIM adoption, highlighted by seven respondents which is similar study by Akmal, Nazareth, Hamimah (2021). Many industry professionals are hesitant to transition away from traditional methods, especially those familiar in using AutoCAD, as they perceive them to be more familiar (R2, R4, R5). Older generations and subcontractors in particular resist adopting BIM, preferring their established practices and finding it challenging to adapt to new technology (R7, R9). This resistance is often due to a lack of understanding of BIM's complexity and benefits, combined with a hesitation to invest time and resources in learning new tools (R1, R8). The resistance to change highlights the challenge of shifting an industry rooted in familiar methods, where people prefer sticking to old tools rather than adopting new technologies like BIM, despite the potential benefits.

4.3.8 Solutions to increase BIM adoption

Table 4.10: Coding Legend for Solutions

Category	**Theme**	**Sub-theme**	**Code**
B. BIM Practice	Organisation	Top management level	B1a
		Cooperation and training	B1b*
		Awareness	B1c
		Technology access	B1d
		Communication	B1e
	Society	Individual willingness	B2a
		Education	B2b
		Government provides financial incentives	B2c*
		Regulatory Framework and Standardization	B2d*
		Professional bodies	B2e*
	Country	Improve currency	B3a

Table 4.11: Coding Matrix of Solutions Determined by Respondents

Category B: BIM Practice										
Theme 5: Solutions to increase BIM adoption										
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**Total respondents**
B1a			/							1
B1b	/	/	/	/	/	/		/	/	*8
B1c		/			/					2
B1d			/	/			/		/	4
B1e	/	/								2
B2a		/								1
B2b	/	/	/			/			/	5
B2c	/	/	/	/	/	/			/	*7
B2d	/	/		/		/	/	/	/	*7
B2e	/	/	/	/		/	/	/	/	*8
B3a							/			1

Table 4.12: Coding Matrix of Solutions Expressed by Respondents

Summaries of Data Transcript	
Category B: BIM Practice	
Theme 5: Solutions to increase BIM adoption	
B1a: Top management level	
R3	*“Top management must provide full support, including resources, training, and clear direction, to facilitate staff learning and successful BIM* application *.”*
B1b: Cooperation (Training)	
R1	*“Effective training and continuous support for staff are crucial, such as the BIM Rail Academy demonstrating successful collaborative training initiatives.”*
R2	*“Offering continuous professional development opportunities and mentorship within firms can enhance the skills of existing practitioners.”*
R3	*“Training is necessary because it's a new thing in Malaysia.”*
R4	*“Providing structured, role*-*specific training courses for modelers, coordinators, and managers, alongside certification through programs like MyBIM and JKR CREaTE Melaka, ensures staff competency in BIM processes and tools, helping to standardize and enhance BIM* application *across disciplines.”*
R5	*“Companies with resources should establish internal BIM departments led by experts to train staff, including architects, demonstrating BIM's time-saving benefits compared to traditional tools like AutoCAD.”*
R6	*“Establish more BIM training centres for students and existing technical staff, with government support to create training hubs that help transition from traditional 2D methods to BIM, ensuring the workforce stays updated with industry advancements.”*
R8	*“Government and professionals should make BIM more attractive by organizing and sponsoring regular training,*

	workshops, and talks to increased awareness and engagement within the industry."
R9	*"Enhance education and training programs to improve understanding and competency, encourage industry collaboration and knowledge sharing, foster public-private partnerships for investment in BIM, and establish formal training programs with certifications to boost professionals' confidence and skills in BIM tools."*
B1c: Awareness	
R2	*"Increasing awareness about BIM's benefits through education, workshops, and industry seminars is crucial."*
R5	*"Raise awareness with industry leaders taking the initiative to lead these efforts."*
B1d: Technology	
R3	*"Implementing BIM on smartphones and tablets can make it more interactive and accessible, allowing engineers to view models in real-time and save time, which enhances the overall attractiveness and efficiency of BIM technology."*
R4	*"To ensure effective BIM* application , *organizations must regularly upgrade technology and computers, plan for ongoing maintenance, and adopt strategies for managing subscription-based software to provide staff with the tools they need for their work."*
R7	*"Technology providers should design BIM software with the preferences of younger generations in mind, making it more appealing and user-friendly, while clients must actively push for its adoption to ensure successful* application *."*
R9	*"Providing cost-effective solutions, such as affordable software options can encourage more firms to invest in BIM technology."*
B1e: Communication	
R1	*"Demonstrating the value of BIM through effective communication and proof of benefits to clients can*

	encourage adoption and foster a collaborative environment among stakeholders."
R8	*"Effective communication and education are crucial to closing the gap between industry players and BIM professionals; by addressing misconceptions and demonstrating the complexities involved, stakeholders can better understand BIM's value and workflow, leading to more realistic expectations and support for project timelines."*
B2a: Individual	
R1	*"Leveraging support from experienced colleagues and investing in continuous learning opportunities are key strategies…"*
B2b: Education	
R1	*"Better way in my opinion will be through better education programmes."*
R2	*"Providing comprehensive BIM training programs in collaboration with educational institutions can help prepare the next generation of professionals."*
R3	*"The government should focus on enhancing university programs by integrating comprehensive BIM training, including advanced software like Revit, to better prepare students and increase their job prospects upon graduation."*
R6	*"BIM specialists should advocate for the integration of BIM-focused syllabus in engineering programs at universities, ensuring students are exposed to both 2D and 3D modelling, including advanced BIM tools."*
R9	*"Enhancing education and training programs on BIM* application *and usage can help improve the overall understanding and competency of industry professionals, fostering wider adoption of BIM technology through accessible and comprehensive resources."*

B2c: Government financial incentives	
R1	*"The government should explore providing tax incentives for technology investments, including training and BIM* application *, to reduce costs and encourage adoption, as seen in discussions between CIDB and industry organizations."*
R2	*"Encouraging government incentives or subsidies for BIM adoption and providing access to affordable training programs can help mitigate the financial burden on smaller firms."*
R3	*"The government need to enforce the grant on the current project."*
R4	*"The government should focus on providing incentives or subsidies to reduce the high costs of BIM software, especially given its foreign currency pricing, and consider options like tax reductions to reduce financial burdens for contractors and consultants."*
R5	*"Providing financial incentives for individuals to upskill and reskill in BIM, along with financial aid for companies to purchase BIM software, can support broader adoption by reducing the cost barriers associated with training and technology."*
R6	*"… a tax relief for company using the BIM."*
R9	*"To increase BIM adoption, address initial cost concerns by providing affordable software options or government subsidies, and enhance regulatory support through incentives, clear guidelines, and policies that promote widespread BIM* application*."*
B2d: Standardization/ government mandate	
R1	*"Government mandates and policies, like those from JKR requiring BIM for certain project values."*
R2	*"Government mandates for BIM in public projects drive industry-wide adoption, while establishing clear data*

	exchange protocols, investing in interoperability tools, and creating clear contractual agreements ensure smooth integration, risk mitigation, and effective BIM workflows."
R4	*"Implementing BIM policies by itemizing BIM requirements in project documentation, mandating its use for government projects, and developing comprehensive guidelines, standards, and technical documentation can drive industry-wide adoption and standardize practices across all government agencies and contractors."*
R6	*"Establishing clear guidelines for BIM* application *through agencies like CIDB or JKR, and mandating BIM for government projects, can drive adoption; however, it's essential to consider project size and cost, as smaller projects may be reluctant to adopt BIM due to perceived expense.*
R7	*"To drive BIM adoption, clients should mandate its use, starting with higher-value projects and progressively including smaller ones, while the government should evolve policies and thresholds to gradually include more projects, ensuring that the benefits of BIM are realized across the industry."*
R8	*"The government should introduce mandatory BIM submission requirements for projects, starting with specific thresholds, and fine-tune the process to ensure comprehensive* application *and compliance, thereby encouraging wider adoption of BIM across the industry."*
R9	*"Improving interoperability between BIM software, establishing clear regulatory support and mandates, and developing standardized guidelines for data sharing and collaboration…."*
B2e: Professional bodies	
R1	*"Gradually lowering BIM adoption thresholds for large projects, as JKR's policy suggests, while expanding training*

	and promotion efforts by CIDB can effectively increase BIM adoption across the industry.”
R2	*“Industry*-wide *certification programs by CIDB standardize BIM competencies and showcasing successful case studies with tangible benefits like improved coordination, reduced rework, and enhanced sustainability can shift perceptions and encourage adoption.”*
R3	*“Offering lifetime certifications by CIDB that demonstrate proficiency in BIM can attract and retain talent, reduce initial training time for companies, and enhance overall industry knowledge and readiness.”*
R4	*“CIDB should intensify efforts to promote BIM awareness and provide certification programs to enhance competency, ensuring that contractors and consultants are well-informed and skilled in BIM practices.”*
R6	*“Conducting awareness campaigns through roadshows, training sessions, and collaborations with authorities like CIDB can significantly boost BIM adoption by educating industry stakeholders and promoting its benefits.”*
R7	*“CIDB promoting BIM through marketing activities such as webinars, conferences, and interactive sessions can raise awareness and engagement while awaiting further government initiatives.”*
R8	*“CIDB can conduct talks, training, workshop ...”*
R9	*“Professional bodies showcasing successful BIM projects and case studies, supporting pilot projects to demonstrate BIM benefits, and establishing formal training and certification programs can enhance industry understanding, build confidence, and drive wider adoption of BIM technology.”*
B3a: Improve currency	
R7	*“Strengthening the Malaysian ringgit to reduce software costs, alongside showcasing successful BIM* application *and*

enhancing training programs, can facilitate wider adoption of BIM technology by making it more accessible."

4.3.8.1 Special findings

For B1c – awareness, Respondent 1 mentioned that:

"So, what we're doing is we're running internal workshops explaining to people what technologies are available, showing them how they can use those technologies, showing them how to identify use cases for those technologies and then helping them to explain to owners why it's beneficial to their project to use these technologies."

Respondent 1's method highlights by providing practical training on technology use, demonstrating the practical application of technology and its benefits to both teams and project owner, ultimately leading to greater acceptance and integration of BIM in projects, a similar idea with Manzoor, et al (2021) and Zaini, et al (2020).

For B2a- individual willingness, Respondent 7 mentioned the rationale behind is:

"To accelerate BIM adoption, it is essential to wait for the older generation to retire and for new, tech-savvy professionals to lead, while also encouraging clients to invest in and mandate BIM for their projects."

The generational shift, with the retirement of older professionals and the emergence of tech-savvy younger leaders, presents a key opportunity to accelerate BIM adoption. This shift, combined with growing client demand for digital solutions, can drive industry-wide change. To support this transition, it is essential to implement targeted training programs and educate clients on the tangible benefits of BIM.

For B2d - standardisation, Respondent 1 mentioned that:

"The most impactful way is when the government says you must do it and we'll pay you when you do it, but it needs to be all three combined. There needs to be some financial incentives, some improvement in training, and there needs to be some government mandates."

Respondent 1 emphasizes that in Malaysia’s construction industry, successful BIM standardization requires a comprehensive approach. Key factors include government mandates, financial incentives, and training programs to facilitate the transition. These measures are especially important for smaller firms, allowing them to adopt BIM without compromising their operations.

For B2d standardization- Respondent 8 also suggest that:

“The government should introduce mandatory BIM submission requirements for projects, starting with specific thresholds, and fine-tune the process to ensure comprehensive application and compliance, thereby encouraging wider adoption of BIM across the industry. For instance, the current submission of drawings to government agencies does not require BIM. However, in the future, firms may be required to submit BIM models instead.”

As mandatory requirements would push firms to adopt BIM more quickly, fostering consistency across projects and accelerating the industry's shift toward more efficient digital practices.

For B2e - Professional bodies, Respondent 1 noted that:

“JKR’s policy is a good policy.”

He further elaborated that:

“JKR has implemented a policy requiring BIM for large projects, targeting big consultancy firms with the resources to train staff. The strategy ensures that these top firms adopt BIM first, gradually extending to smaller companies as industry expertise grows. As more firms gain BIM competency, the threshold for mandatory BIM use will be lowered to include smaller projects. This approach ensures that larger firms lead the way while preventing industry disruption due to a lack of skilled personnel.”

This phased approach enables larger firms to establish industry benchmarks for BIM adoption, while professional bodies such as CIDB and JKR play a pivotal role by offering training initiatives, certification programs, and technical guidelines. This support ensures that smaller firms can gradually adopt BIM without creating a skills gap, and at the end stop people jump between companies. Furthermore, a new "New Construction Technologies Committee," headed by the ministry's secretary-general, will be established to standardize the use of BIM and other advanced technologies in road and building projects (Allison and Gerard, 2024).

Respondent 9 also stated that:

"Professional bodies can showcase successful BIM projects, share lessons learned, and highlight the benefits and value in project outcomes. These examples can serve as models for future projects and inspire other companies to adopt BIM."

By doing so, professional bodies can build confidence in BIM's effectiveness, helping to overcome resistance and demonstrate how it can improve efficiency and project success.

4.3.8.2 Discussion

Eight respondents emphasized the vital role of professional bodies (B2e) like CIDB in promoting BIM adoption. Key solutions included lowering project thresholds (R1), offering certification programs to standardize BIM skills (R2), and providing lifetime certifications to attract talent and reduce time needed for upskilling (R3). Their efforts, including awareness campaigns, webinars, roadshows and lifetime certification options (R4,6,7,8), help ensure BIM competencies are standardize across the workforce (R9, Zaini, et al, 2020). These initiatives aim to create a skilled workforce, shift perceptions, and align with government and industry goals for sustainability and technological progress.

Another first highest solutions mentioned by eight respondents is the importance of training (B1b) and continuous professional development for effective BIM adoption in Malaysia. Collaborative training initiatives, like the BIM Rail Academy (R1), and continuous professional development and mentorship (R2) are seen as crucial to building skills in the industry. Given BIM's relatively new status in Malaysia as industry people work in 2D for quite a long time(R3), structured, role-specific training programs such as those offered by MyBIM and JKR CREaTE Melaka are necessary to ensure staff competency across disciplines (R4). Collaboration efforts between larger firms, government agencies like MyBIM, and educational institutions such as JKR CREaTE Melaka is essential for delivering structured, role-specific BIM training. Larger companies can lead these efforts by creating in-house training departments that demonstrate BIM's efficiency and time-saving advantages over traditional tools like AutoCAD, fostering broader industry adoption (R5). Expanding BIM training centres and government-supported hubs for students and technical staff (R6), as well as sponsoring regular workshops and talks (Manzoor, et al, 2021, R8), are also recommended to transition from traditional methods to BIM. Enhanced education and training, public-private partnerships, and formal certifications can improve skills, foster collaboration, and boost industry confidence in BIM tools (R9). Also, establishing industry networks and platforms for knowledge exchange can significantly promote wider BIM adoption. This approach is crucial for aligning industry practices with global standards, fostering innovation, and ensuring Malaysia's workforce remains competitive in a technologically evolving construction sector.

The second highest solution mentioned by seven respondents is the need for government financial incentives (B2c) to boost BIM adoption in Malaysia. Respondents 1,2,4 suggested implementing tax incentives, subsidies, and grants to reduce the initial costs of BIM adoption similar to strategies used in other industries like manufacturing, where government-backed grants and subsidies have been effective in driving technology adoption. Financial aid for both companies and individuals to purchase software and upskill (R3, R5) was also emphasized as critical to wider adoption. Furthermore, tax relief and affordable software options (R6, R9) were highlighted as ways to reduce cost barriers. This reflects the broader need for government intervention to make BIM more accessible and cost-effective, aligning with national economic development goals and fostering industry modernization.

Another significant solution mentioned by seven respondents is the importance of government mandates and standardization (B2d) for driving BIM adoption in Malaysia. Government policies like JKR's mandate for BIM on certain project values (R1), along with establishing clear guidelines and technical documentation (R4), are essential to ensure smooth integration and standard practices across agencies and contractors. R2 and R6 emphasized the need for clear data exchange protocols and interoperability tools, while mandating BIM use in government projects. Respondents 7 and 8 also noted that introducing BIM mandates for larger projects, where it is required for public and private projects above 10 million, could serve as a model for Malaysia. Gradually extending these mandates to smaller projects would enable the construction industry to adopt BIM at scale without overburdening smaller firms, ensuring a more seamless transition. Standardization through mandates and regulatory support ensures a consistent approach across the industry, driving widespread BIM use and aligning with national development goals (R9). This approach reflects the need for government leadership to standardize BIM practices, align with industry capabilities, and overcome barriers related to cost and scale for smaller projects.

4.3.9 Key trends shape the future of BIM in next 5-10 years

Table 4.13: Summary of key trends

Category C: Future Plans	
Theme 1: Key trends that shape future of BIM in next 5-10 years	
Respondents	**Data Transcript**
R1	*"The industry is expected to gradually transform over the next five to ten years with the injection of tech-savvy youth bringing affordable and advanced technologies like 360 video cameras, drones, and laser scanning into day-to-day construction, while AI remains a distant influence, with significant impact anticipated in the future."*
R2	*"The future of BIM adoption will be driven by mandatory government application, private sector uptake, refined Levels of Detail (LOD), integration with AI and digital twins, enhanced industry collaboration through open standards, and a strong focus on sustainability and life cycle assessments for greener building practices."*
R3	*"Over the next five to ten years, BIM adoption will expand as costs decrease and more professionals are trained, particularly in mega projects, leading to easier application with reduced training needs, where engineers focus on design and coordination while drafters specialize in tools like Revit, ensuring smoother transitions across projects."*
R4	*"While the integration of advanced technologies like AI, cloud-based BIM, and prefab models offers significant potential, Malaysia is currently behind other countries, with challenges in government application and industry adoption, but there is hope for progress in the next five to ten years if more aggressive promotion and digital construction initiatives are undertaken."*
R5	*"While awareness of technologies like AI, AR, and VR in BIM is currently limited, these tools, along with cloud-based scanning and sharing, have the potential to significantly reduce time, cost, and improve collaboration in the*

	Malaysian construction industry if widely adopted and understood."
R6	*"Over the next five to ten years, integrating AI with BIM will be crucial for addressing issues in the 2D to 3D transition, improving design accuracy, and training more specialists; government support and university-level BIM education will also be vital to ensure widespread adoption in the construction industry."*
R7	*"The increasing integration of AI into BIM tools, like AI-driven takeoff software, is expected to shape the future of BIM adoption, with AI potentially enhancing efficiency and accuracy, ultimately driving widespread application across the entire construction market in Malaysia, including SMEs."*
R8	*"The future trend for BIM is its full application across the entire building lifecycle, from pre-design to demolition with growing interest in digital twins, enabling continuous use of BIM data for operations, maintenance, safety, and refurbishment, potentially becoming widely adopted within the next two to three years as more clients recognize its benefits."*
R9	*"Over the next 5-10 years, key trends such as government mandates, Integrated Project Delivery (IPD), smart cities and sustainability initiatives, advanced technology integration (including VR, AR, IoT, and AI), skills development, and cloud-based collaboration will significantly shape BIM adoption in Malaysia, driving digital transformation, enhancing project efficiencies, and improving industry competitiveness."*

4.3.9.1 Discussion

Key trends shaping BIM adoption in Malaysia include the increasing roles of advanced technologies like AI, AR, VR, and IoT (R1, R2, R4, R5, R6, R7, R9). Respondents 7 and 9 highlighted the potential of AI-driven software to improve accuracy, while cloud-based platforms are expected to transform collaboration and project management. Advanced technologies like AI-powered take-off software significantly enhance the cost estimate accuracy and speed, while AR and VR are revolutionizing project planning with immersive design simulations (Sharen, 2024). The integration of technologies like BIM, 3D printing, and AI is critical to transforming the construction industry in Malaysia (Aris, 2024).

Sustainability is another key trend, emphasized by Respondent 2 and 8 (Manzoor, et al, 2021). BIM's integration with sustainability practices is demonstrated with digital twins, which enable continuous monitoring of a building's energy performance. By offering real-time data on energy consumption and maintenance, BIM helps minimize waste and enhance the environmental performance of structures, supporting Malaysia's increasing focus on eco-friendly infrastructure. This aligns with global environmental concerns and the push for eco-friendly construction solutions in the industry.

Other influential factors include government mandates (R2, R4, R6, R9), industry collaboration (R2, R9), skills development (R3, R6, R9), and innovative project delivery methods like IPD (R9). Government support is essential for advancing BIM adoption in the industry. Malaysia's recent policy mandating BIM for large-scale government projects compels firms to integrate BIM into their workflows. Additionally, partnering with universities (R6, R9) to develop domestic BIM software will decrease dependence on expensive foreign programs, making BIM more accessible and affordable for local firms. The government aims to collaborate with universities to create own BIM software to reduce reliance on costly overseas systems (Allison and Gerard, 2024). Skills development is crucial for the effective application of BIM in Malaysia. Respondents emphasized the need for targeted training programs focusing on data management, BIM software proficiency, and collaborative practices. To address this, universities should partner with industry to develop specialized courses and certification programs that equip professionals with these essential skills. Innovative project delivery methods like Integrated Project Delivery (IPD) complement BIM's collaborative approach by encouraging early and continuous collaboration among project stakeholders. IPD enhances BIM's effectiveness by integrating teams, sharing digital models, and enabling real-time data exchange, which collectively improve project outcomes.

4.3.10 Further plan for BIM adoption

Table 4.14: Summary of further plan

Category C: Future Plans	
Theme 2: Further plan for BIM adoption	
Respondents	**Data Transcript**
R1	*"Training is essential, and the focus is now on integrating advanced technologies such as drones, augmented reality, virtual reality, and laser scanning, beyond basic BIM modelling, for select existing and future projects."*
R2	*"We aim to enhance BIM adoption through comprehensive training programs, integration of advanced features like 4D scheduling and 5D cost estimation, pilot projects to demonstrate BIM benefits, partnerships with industry experts, and continuous improvement through feedback and post-project reviews."*
R3	*"We aim to fully* utilize *BIM by implementing it from the early planning and tender stages, allowing for earlier coordination, reducing time and costs, improving accuracy in quantity take-offs, and minimizing issues during construction, ultimately streamlining the entire project process."*
R4	*"We aim to expand BIM usage towards digital construction by enhancing staff competency, collaborating with industry partners, vendors, and private sectors, and developing national BIM data and standards, while addressing current challenges like interoperability, with plans to accelerate* application *in line with government directives."*
R5	Not applicable
R6	Not applicable
R7	*"While BIM adoption is already in place, the plan now is to expand the focus beyond profitability and waste reduction to include embodied carbon estimates, integrating climate change, net-zero, and carbon tracking into the project evaluation process."*

R8	*"The company is exploring BIM Stage 3, with background work in progress, and plans to implement tools like Dynamo to enable more autonomous modelling and reduce repetitive tasks, while also preparing for future project demands and training staff, although full* application *has not yet been achieved."*
R9	*"To expand BIM adoption, companies should secure leadership support, invest in training, standardize workflows, encourage collaboration, run pilot projects, and regularly evaluate performance, fostering continuous improvement and wider* application*."*

4.3.10.1 Special findings

Respondent 1 emphasised that

"We're depending on the clients to drive it. So, if the clients are not willing to pay for it, then it becomes a challenge because it's an anxiety proposition."

Respondent 1 notes that if clients don't fund BIM, its adoption struggles because the financial risk deters progress.

Respondent 7 mentioned that

"Currently, the strategy involves conducting research and collaborating with external parties to explore embodied carbon integration, sharing ideas and technologies, and developing case studies."

The strategy focuses on embodied carbon integration to meet environmental goals, reduce carbon footprints, and align with global sustainability efforts driven by social and governmental pressures.

4.3.10.2 Discussion

Respondents outlined several key strategies for expanding BIM adoption in the future. R1 and R2 emphasize the need for comprehensive training programs and integrating advanced technologies like drones, AR/VR, and laser scanning to improve BIM capabilities. Government or Professionals should make BIM more attractive so that university students are interested. R2 highlights successful examples such as the pilot project by PYLTEC Construction, which achieved significant enhancements in project coordination and substantial cost savings through the integration of BIM. Additionally, industry partnerships, such as the collaboration between IJM Firm and Curtin University, have led to the creation of innovative BIM techniques, demonstrating the value of ongoing collaboration and iterative feedback. R3 focuses on implementing BIM from the early stages of projects to enhance coordination, reduce costs, and improve accuracy, which streamlines the entire process and demonstrates the long-term efficiency benefits of BIM.

R4 emphasizes the importance of establishing national BIM standards to tackle interoperability issues, including the application of unified data exchange protocols. R7 advocates for the development of specialized training programs to improve staff proficiency in using these standards. Meanwhile, R9 proposes creating industry-wide forums to facilitate the exchange of best practices and address interoperability challenges collaboratively. R7 highlights the need to include environmental factors such as carbon tracking and climate change into BIM evaluations. R9 recommends securing leadership support by showcasing the strategic advantages of BIM through detailed case studies and aligning BIM initiatives with the organization’s goals. Leaders can accelerate adoption by championing BIM, allocating essential resources, and advocating for industry-wide standardization and pilot projects. These plans reflect an understanding that collaboration, leadership, and environmental responsibility are key to driving BIM adoption at both the company and national levels.

4.3.11 Will BIM become norm in future

Table 4.15: Summary of will BIM become norm in future

Category C: Future Plans	
Theme 3: will BIM become norm in future	
Respondents	**Data Transcript**
R1	Not applicable
R2	Not applicable
R3	Not applicable
R4	*"Over the next 5-10 years, BIM is expected to become the standard in Malaysia as the construction industry transitions from 2D to 3D modelling, driven by the need for global competitiveness, sustainability, and efficiency, much like in countries where BIM is already mandatory or widely accepted, while also preparing for international competition under agreements like Free Trade Area of the Americas (FTAA)."*
R5	*"BIM is expected to become a standard practice as it attracts more professionals due to higher salaries compared to traditional architectural roles, making it increasingly appealing and potentially accelerating its adoption over time."*
R6	*"BIM is projected to be used in 80-85% of future projects due to its cost-saving benefits and efficiency improvements, despite the current challenges of high* application *costs, lack of incentives, and resistance to transition from traditional methods."*
R7	*"While BIM is expected to eventually become a norm in Malaysia, the timeline remains uncertain due to current slow adoption compared to faster-moving countries like Singapore."*
R8	*"BIM is expected to become a crucial component in the construction industry, with its integration into meetings and decision-making processes enhancing visualization, problem-solving, and design, supported by advancements such as AI-driven conceptual design features."*

R9	*"Despite challenges in training, investment, and change management, BIM is set to become an integral part of organizational culture in the Malaysian construction industry, with its adoption by key organizations like JKR and CIDB providing a competitive edge and driving sustained growth and innovation."*

4.3.11.1 Discussion

BIM is expected to become a standard practice in Malaysia within the next 5-10 years, driven by several key factors. These include the Malaysian government's push for digital transformation in construction, new regulations mandating BIM usage, and the adoption of advanced technologies like AI and IoT. Combined with global competitiveness and sustainability objectives, these trends will likely propel BIM to widespread adoption, similar to its established use in the UK and Singapore (R4). Despite significant challenges such as high application costs and resistance to change, various strategies are being used to address these issues. Government subsidies and financial incentives are being introduced to mitigate the high initial costs of BIM adoption. Concurrently, comprehensive training programs and awareness campaigns are being developed to tackle resistance by highlighting BIM's tangible benefits, including enhanced project efficiency and increased salaries for skilled professionals (R5, R6). These measures are anticipated to accelerate BIM adoption by making it more accessible and appealing to industry stakeholders.

4.4 Results of Questionnaire

4.4.1 Background of Respondents

The study primarily used online surveys distributed via Facebook, LinkedIn, and email to collect data from construction professionals in the Klang Valley region. Approximately 161 completed surveys were analysed, with 19 respondents excluded due to a lack of BIM experience. Demographic data, including work experience and organization size, is presented in Table 4.17. The Central Limit Theorem was applied to justify using the 161-sample size instead of the full 384.

The majority of respondents (41%) had less than two years of construction experience, while only 5% had over 20 years. Quantity Surveyors made up the largest group of respondents (28.6%), followed by Engineers and Architects. Most respondents (29.2%) worked for large companies, while a smaller percentage (16.1%) worked for small enterprises.

Table 4.16: Respondents' Attributes (N=161)

Information	Categories	Frequency	Percentage (%)
Working Experience	0-2 years	66	41.0
	3-5 years	48	29.8
	6-10 years	19	11.8
	11-20 years	20	12.4
	More than 20 years	8	5.0
Profession	Quantity Surveyor	46	28.6
	Engineer	42	26.1
	Architect	35	21.7
	Contractor	11	6.8
	Developer	4	2.5
	BIM Specialist*	17	10.7
	Designer	2	1.2
	Drafter	2	1.2
	Solution consultant	1	0.6
	Multidiscipline	1	0.6
Organisation size	Small (1-19 people)	26	16.1
	Small to medium (20-50 people)	46	28.6
	Medium to large (51-200 people)	42	26.1
	Large (more than 200 people)	47	29.2

N= Total number of respondents

*BIM Specialist included BIM Modeller, BIM Coordinator, BIM Manager, BIM Director

4.4.2 Normality of Data

The normality tests revealed that all data subsections were not normally distributed (p-value < 0.05). Therefore, non-parametric statistical tests will be used. Table 4.18 summaries the normality test results.

Table 4.17: Summary of Normality Test Results

Sections	Sub Section	Sig.
A: Demographic	Working Experience	0.000
	Role	0.000
	Size of organisation	0.000
B: Current application	Familiarity for BIM software	0.000
	Application for BIM software	0.000
	BIM used in organisation	0.000
	Source of information about BIM	0.000
	How enthusiastic to participate if BIM training open	0.000
	Agree that BIM provides benefits for project application	0.000
	Willingness to change for BIM adoption	0.000
	Organisation aware & adopting BIM	0.000
C: Barriers	Barriers of BIM application	0.000
D: Solutions	Solutions to increase BIM adoption	0.000

4.4.3 Reliability Analysis

Table 4.19 shows that all subsections have a Cronbach Alpha value greater than 0.7, indicating high internal consistency and reliability of the survey. The number of items for Sections B, C, and D can be referenced in Appendix C: Questionnaire. Additionally, the items from Sections B and E of Appendix C have been combined into Section B for the final number of items.

Table 4.18: Summary of Reliability Test Results

Sections	Cronbach's Alpha	Number of Items	Results
B: Current application	0.889	47	Good
C: Barriers	0.809	12	Good
D: Solutions	0.912	10	Excellent

4.4.4 Barriers hindering wider application of BIM

Table 4.20 displays the mean ranking of the targeted respondents for the barriers hindering wider application of BIM.

Table 4.19: Mean ranking of barriers

Code	Barriers	Mean	Standard Deviation	Ranking
B3	High initial and training cost	4.15	0.882	1
B8	Resistance to change	4.03	0.984	2
B11	Lack of BIM skilled workers	4.03	0.918	2
B9	Lack of education & training	3.96	0.990	4
B10	Lack of BIM benefits awareness	3.86	1.018	5
B11	Lack of time to implement	3.80	1.024	6
B2	Complexity of BIM model	3.75	0.902	7
B6	Lack of industrial standards	3.68	1.003	8
B7	Intellectual property rights and ownership of BIM	3.65	0.861	9
B1	Lack of interoperability	3.63	0.893	10
B5	Lack of government involvement	3.58	1.064	11
B4	Return on investment (ROI) not clearly defined	3.56	0.954	12

Table 4.20 presents the mean rankings of the barriers identified by respondents, with high initial and training costs (B3) emerging as the most significant barrier (mean = 4.15). This highlights the financial burden that firms face when implementing BIM, particularly for SMEs. Similar findings were observed by Akmal et al. (2021) and Jamaludin et al. (2022), underscoring the global nature of this challenge. The cost barrier is not just about purchasing software or hardware; it also includes ongoing expenses related to training and upgrading systems to handle the complexities of BIM. Strategies such as government grants, tax incentives, or educational partnerships could help lighten these costs.

Resistance to change (B8) and lack of skilled BIM workers (B11) tied for second place (mean = 4.03). Resistance to change, as noted by Waqar et al. (2023) and Demirkesen and Tezel (2022), reflects the traditional nature of the construction industry, where established practices are often preferred over adopting new technologies. Change management strategies, led by strong leadership, are critical to overcoming this resistance. On the other hand, the shortage of skilled workers underscores the gap between the growing demand for BIM expertise and the limited availability of qualified professionals. This barrier could be overcome by creating targeted BIM training programs or collaborating with educational institutions to ensure a steady supply of skilled workers into the industry.

In contrast, unclear return on investment (B4) ranked lowest (mean = 3.56), suggesting that while firms acknowledge the costs, they may not fully grasp the long-term savings BIM can offer (Yaacob et al., 2024). This knowledge gap can be addressed through industry-specific case studies or pilot projects that demonstrate the tangible ROI of BIM in reducing errors, improving coordination, and speeding up project delivery. Such initiatives could significantly improve the perception of BIM’s value.

4.4.5 Solutions to increase BIM adoption

Table 4.21 shows the mean ranking of the targeted respondents for the solutions to increase BIM adoption.

Table 4.20: Mean ranking of solutions to increase BIM adoption

Code	Solutions	Mean	Standard Deviation	Ranking
S1	Top management support	4.53	0.652	1
S4	Cooperation by training	4.45	0.660	2
S6	Technology access	4.40	0.693	3
S3	Team capability	4.38	0.689	4
S5	Industry awareness	4.36	0.787	5
S9	Government initiatives	4.34	0.783	6
S10	Standardization efforts	4.34	0.724	6
S8	Education	4.32	0.754	8
S2	Project preparation	4.30	0.699	9
S7	Individual motivation	4.18	0.720	10

Table 4.21 presents the mean ranking of the solutions identified by respondents. Top management support (S1), with a mean of 4.53, is recognized as the most critical factor for increasing BIM adoption. This suggests that leadership plays a pivotal role in creating the necessary conditions for successful BIM application. When management demonstrates a clear commitment to BIM, it fosters a culture of innovation and ensures that employees have the resources and motivation to adopt new technologies (Zaini et al., 2020; Ahmed et al., 2022). For example, companies that have embedded BIM into their corporate strategies often allocate dedicated budgets for BIM tools and training programs, setting up specialized BIM teams to manage application. In contrast, organizations lacking this leadership commitment often struggle to move beyond traditional methods.

Cooperation by training (S4) is the second-highest ranked solution, with a mean of 4.45, highlighting the importance of ongoing skills development. Training programs are crucial for equipping employees with the competencies needed to utilize BIM effectively, and partnerships with educational institutions or software vendors can enhance the quality and accessibility of training

(Shojaei, Oti-Sarpong and Burgress, 2022). This highlights that training should not be a one-time effort but an ongoing process that evolves with the technology.

Despite ranking lower with a mean of 4.18, individual motivation (S7) still plays an essential role in BIM adoption (Ashmori, et al., 2020). While respondents believe personal initiative is important, it is less influential than organizational support and structured training. Therefore, organizations should focus on creating incentives that encourage individuals to enhance their BIM skills, such as certifications, rewards, or career advancement opportunities. However, it is important to note that individual motivation is often a product of the organizational environment when employees see that leadership supports and invests in BIM, they are more likely to be motivated to engage.

While top management support and training are ranked as more critical, these factors are interdependent. Without motivated individuals, even the best training programs can fall short. Similarly, without strong leadership, individuals may lack the motivation to invest time in learning BIM. Therefore, the success of BIM adoption relies on a combination of management commitment, training, and individual motivation, highlighting the need for a whole strategy to drive change.

4.4.6 Kruskal-Wallis Test

The Kruskal-Wallis test was used to compare how respondents' perceptions of BIM barriers varied based on their demographics (Architect, Engineer, Quantity Surveyor). Table 4.22, 4.24 and 4.26 lists the statistically significant differences ($p < 0.05$) between groups.

Table 4.21: Significant items for Current application

Code	Current application	Kruskal-Wallis H	Assump sig.
F1	Familiar with BIM Software (Autodesk Revit)	12.948	0.012*
F3	Familiar with BIM Software	10.014	0.040*

	(Autodesk Navisworks)		

*Grouping variable is willingness to change for BIM adoption.

Table 4.22: The mean value for significant items

Code	Current application	Willingness to change for BIM adoption	Mean value
F1	Familiar with BIM Software (Autodesk Revit)	Highly resistant	120.63
		Somewhat resistant	134.00
		Neutral	61.12
		Willing	72.78
		Highly willing	88.27
F3	Familiar with BIM Software (Autodesk Navisworks)	Highly resistant	131.38
		Somewhat resistant	91.50
		Neutral	71.27
		Willing	71.84
		Highly willing	87.90

Among respondents familiar with Autodesk Revit, the average resistance score was 134, indicating a moderate level of resistance to BIM adoption. In comparison, those familiar with Autodesk Navisworks had a slightly lower average resistance score of 131.38. These scores suggest that respondents' openness to BIM adoption varies based on their familiarity with different software. Given that familiarity with specific BIM tools affects resistance levels, organizations should implement customized training programs. For Autodesk Revit users, advanced modules can deepen their understanding of BIM's capabilities, while practical application workshops for Autodesk Navisworks users can demonstrate the benefits of integration. Providing ongoing support through user forums and helpdesks will also address concerns and ensure a smoother transition.

Respondents familiar with both Autodesk Revit and Navisworks generally show a greater inclination towards adopting BIM compared to those with less experience. However, moderate resistance levels persist, highlighting the need for targeted interventions. Differences in resistance may arise from individual preferences and learning styles; for example, some may find Revit's interface more intuitive, while others struggle with its complexity. Similarly, Navisworks users may feel its functionality doesn't align with their needs, increasing resistance. A limited understanding of BIM's benefits, along with concerns about cost and complexity, can also contribute to these challenges. Tailored training and support can help overcome these barriers, facilitating smoother adoption across diverse user groups.

Table 4.23: Significant items for Barriers

Code	**Barrier**	**Kruskal-Wallis H**	**Assump sig.**
B2	Complexity of BIM model	7.656	0.022*

Table 4.24: The mean value for significance items

Code	**Barrier**	**Role in construction industry**	**Mean value**
B2	Complexity of BIM model	Quantity Surveyor	72.45
		Engineer	54.12
		Architect	57.73

Table 4.25 shows that Quantity surveyor think that complexity of BIM model is the major barriers of hindering BIM adoption with mean value of 72.45. It then followed by Architect, 57.73 and Engineer 54.12. These scores indicate the varying levels of concern across different professions regarding BIM model complexity. Quantity Surveyors perceive the complexity of BIM models as a major barrier to BIM adoption because it can complicate cost estimation, require more detailed and precise data, and involve additional training to fully understand and manage the models. The integration of detailed 3D models into

cost calculations introduces complexities that differ from traditional methods, making it harder to apply standard quantity surveying techniques.

Architects and Engineers also perceive BIM model complexity as a concern, though less pronounced than for Quantity Surveyors. Architects deal with detailed design elements, and Engineers handle complex systems and integrations, making them accustomed to managing complex details. However, the additional layer of detail and coordination required by BIM can still present challenges. Their slightly reduced concern may be attributed to their extensive experience with complex designs and technical skills, which helps them navigate some of the complexities associated with BIM more effectively. Conversely, Quantity Surveyors face the challenge of translating these detailed models into accurate cost estimates, adding an additional layer of complexity and raising their level of concern.

Table 4.25: Significant items for Solutions

Code	**Solution**	**Kruskal-Wallis H**	**Assump sig.**
S10	Standardization & effort	9.333	0.009*

Table 4.26: The mean value for significance items

Code	**Solution**	**Role in construction industry**	**Mean value**
S10	Standardization Efforts	Quantity Surveyor	58.85
		Engineer	73.75
		Architect	52.04

Table 4.27 reveals that the most preferred solution is S10 - Standardization Effort, with a mean score of 73.75, indicating a strong industry preference for establishing uniform guidelines. This is followed by solutions favoured by Quantity Surveyors (58.85) and Architects (52.04). The high preference for standardization underscores its importance in simplifying collaboration and

ensuring consistent BIM processes across the industry. Quantity Surveyors see standardization as essential for streamlining cost estimation, while Architects value it for providing clear design and modelling guidelines that align with industry standards.

4.4.7 Discussion for open-ended questions

The main barriers to BIM adoption include the high costs associated with its application, which poses a significant challenge for smaller companies as the similar finding by Zulkifli, et al. (2024). Additionally, there is a general lack of participation and willingness from some individuals to embrace the technology (Yaacob, et al., 2024). Many companies are hindered by the absence of formalized processes for BIM integration, and the shortage of accessible learning resources beyond traditional training programs further complicates the situation. Another critical barrier is the lack of skilled personnel capable of effectively using BIM (Roseli, et al., 2024), and in many cases, BIM is not well-integrated into existing project planning workflows, limiting its potential benefits. Stakeholders, including the government, recognized the importance of BIM. While JKR had mandated BIM usage for government mega projects, contractors often lacked the necessary expertise and outsourced BIM tasks to consultants.

To promote wider BIM adoption, respondents emphasized the need for increased involvement in projects, which can help companies and individuals experience the advantages of BIM firsthand. Improving access to learning resources, such as online tutorials and interactive platforms, can also facilitate more effective training (Tsai, Chen and Chang, 2019). Respondents further suggested that the government should play a more active role by enforcing BIM usage through regulations (Ariono, Wasesa, Dhewanto, 2022) or penalties for non-compliance, which could help drive more consistent and widespread adoption across the industry.

4.4.8 Discussion on Findings

Both interviews and questionnaires reveal that, while there is increasing familiarity with BIM software and a growing trend of its adoption, there remains considerable potential for improvement across the industry. The questionnaire results indicate that respondents who are already familiar with BIM often show more resistance to change. This is likely because switching from traditional methods to BIM comes with significant challenges and costs, making the transition more difficult for those who are accustomed to older processes. Despite understanding BIM's benefits, the effort and expenses involved in making the shift can create hesitation among professionals. The top three barriers are consistent across both methods due to the significant financial and cultural shifts required for BIM adoption, compounded by a limited talent pool, making it difficult to overcome these hurdles.

Both interviews and questionnaires identified high initial and training costs, resistance to change, and a shortage of skilled BIM workers as the top three barriers to BIM adoption. In the questionnaire, high initial and training costs had the highest mean rank of 4.15, followed by resistance to change and lack of skilled workers, both at 4.03. Similarly, in the interviews, eight respondents highlighted high costs and a shortage of skilled workers, while seven respondents mentioned resistances to change.

Both the interviews and questionnaires emphasize that training and collaboration are key to increasing BIM adoption. Training was the most commonly suggested solution in the interviews, and it ranked as the second most important factor in the questionnaire. This highlights the need for better education and teamwork to encourage wider use of BIM in the industry. In the interviews, it was the most mentioned solution, cited by eight respondents, while in the questionnaire, it ranked second with a mean score of 4.45.

The integration of both qualitative and quantitative findings strengthens the overall analysis, showing a clear alignment between the two data sources. The consistent identification of the same key barriers and solutions across methods emphasizes the urgency of addressing high costs, resistance to change, and skill shortages. Focusing on training and fostering collaboration will be crucial in overcoming these challenges and driving wider BIM adoption across the industry.

4.5 Summary

This chapter outlines both qualitative and quantitative data collection processes. It begins by providing the background of interviewees and detailing the main themes and sub-themes derived from the interviews, followed by a presentation of the interview findings. The qualitative data is then analysed using thematic analysis. For quantitative data, the chapter describes respondent backgrounds and evaluates the reliability of the collected data. Also, the data is analysed using the Kruskal-Wallis test. Lastly, the chapter includes a discussion of the open-ended questions and presents findings from both qualitative and quantitative approaches.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summaries the whole research's findings. Section 5.2 details how the research aims and objectives were achieved, comparing findings with the objectives. Section 5.3 discusses the implications for individuals, governing bodies, and academic communities. Section 5.4 outlines the research limitations, such as sample size and limited open-ended responses. Finally, Section 5.5 offers recommendations for future studies, suggesting a larger sample size and explore beyond Malaysia.

5.2 Accomplishments

A literature review was conducted to explore application and performance of BIM in Malaysian Construction Industry. Data from 161 questionnaire responses by construction professionals were analysed using SPSS, along with interviews conducted with nine professionals. To conclude, the achievement of the research objectives is outlined as follows. For research objective 1, the findings reveal that BIM is predominantly adopted by larger firms for large-scale infrastructure projects, while smaller firms and certain projects show low adoption. Key projects such as MRT2 demonstrate significant BIM integration, with an increasing number of firms transitioning to cloud-based BIM solutions. For research objective 2, the challenges hindering wider BIM application are categorized into five key themes: technological, financial, policy, people, and process, with subthemes detailed in Table 4.10. Finally, for research objective 3, the solutions to increase BIM adoption are grouped into three main themes: organization, society, and country, with subthemes outlined in Table 4.13. The research successfully accomplished the research objectives.

5.2.1 Research Objective 1: To examine the current application of BIM in the Malaysian construction industry

The current application of BIM in the Malaysian construction industry involves visualizing building structures in 3D using BIM tools, with project files frequently shared in digital formats among internal stakeholders such as JCloud which is JKR own platform for security purpose. The industry operates mainly between BIM Level 1 and BIM Level 2. Larger companies and engineer are leading the adoption of BIM as shown in Table 4.27, indicating they have high awareness on BIM. However, to increase BIM adoption, there is a need for professionals to have open mindset. Respondents identified training, government incentives, and standardization as important factors, while individual willingness was seen as less crucial for increasing BIM adoption. These findings demonstrate that Research Objective 1 has been achieved by providing a clear analysis of the current BIM practices and adoption levels in the industry.

5.2.2 Research Objective 2: To investigate barriers hindering the process of BIM application in the Malaysian construction industry

Through this study, several key barriers to BIM application in the Malaysian construction industry were identified, grouped into five main themes: Technological, Financial, Policy, People, and Process. The results from both the questionnaire and interviews show a strong alignment, reinforcing the reliability of the findings.

In the Technological theme, the complexity of BIM models emerged as a significant challenge, with a mean value of 3.75 in the questionnaire and four interviewees citing it as a barrier. This reflects the difficulty many users face in managing and utilizing complex BIM tools, a point also supported in previous studies on BIM adoption.

Financially, the high initial and training costs stood out as the most frequently mentioned barrier, achieving the top rank in both methods (mean value of 4.15 in the questionnaire, mentioned by eight respondents in interviews). This is consistent with the literature, which often cites cost as a major obstacle, especially for small and medium-sized enterprises in developing countries.

Under the Policy theme, the lack of industry standards was a critical issue, noted by seven interview respondents and supported by a mean value of 3.68 in the questionnaire. This indicates a need for stronger regulatory frameworks to ensure uniform BIM practices across the industry.

The People theme revealed that the lack of skilled workers (mean value 4.03) and resistance to change were substantial barriers. Both were consistently raised across the questionnaire and interviews, with eight respondents highlighting the shortage of skilled professionals. This points to an urgent need for targeted educational and training programs.

Finally, the Process theme identified inadequate education and training (mean value 3.96) as a major hindrance to BIM application. This suggests that even when BIM technology is available, insufficient knowledge prevents its effective use.

Interviewees highlighted several current barriers in the construction industry, including companies' reluctance to invest in staff training due to concerns about turnover, the lack of incentives for using BIM to work faster and smarter, and the tight budgets imposed by the industry’s contractual framework. Additionally, universities produce insufficient BIM-trained graduates, there is a shortage of qualified leaders for BIM departments, and many contractors misunderstand BIM, assuming it is easy or being unaware of its purpose. Interviewees also noted that many clients remain unaware of BIM’s benefits, which further hampers its adoption as they are not pushing for its use in projects. Moreover, some public universities have yet to incorporate BIM software into their curriculum, limiting the future workforce's exposure to this technology. Furthermore, privacy and security of cloud-based platform remain significant challenges. Future challenges include integrating BIM with advanced technologies such as AI, machine learning, and cloud technology.

These findings clearly fulfill Research Objective 2, as they provide a comprehensive investigation of the barriers hindering BIM application in Malaysia. The consistent evidence from both questionnaires and interviews, combined with support from existing literature, strengthens the conclusion that these barriers are critical to the slow adoption of BIM in the Malaysian construction industry.

5.2.3 Research Objective 3: To identify solutions to increase the adoption of BIM in the Malaysian construction industry

Through this study, several key solutions to improve BIM adoption in the Malaysian construction industry were identified and grouped into three main themes: Organization, Society, and Country. The findings from both the questionnaire and interview responses show notable consistency, strengthening the reliability of these recommendations.

In the Organization theme, cooperation and training emerged as the most mentioned solution, with a mean value of 4.45 in the questionnaire and eight respondents citing it in the interviews. This highlights the critical need for companies to collaborate more closely and invest in regular training programs to develop BIM competencies. These findings align with the existing literature, which emphasizes the role of ongoing skill development and inter-organizational collaboration in driving successful BIM application.

At the Society level, respondents identified government support in the form of financial incentives and the establishment of a regulatory framework as essential. These were consistently ranked high, with a mean value of 4.34 in the questionnaire and seven interviewees agreeing. This underscores the crucial role that government intervention plays in facilitating BIM adoption by reducing financial burdens and setting clear industry standards. The literature also supports this, noting that strong regulatory frameworks and financial backing are common drivers of BIM success in other countries.

At the Country level, the single most mentioned solution was improving the national currency, which was raised by one respondent in the interviews. While this was less frequently mentioned, it does point to the broader economic factors that may indirectly influence BIM adoption by affecting affordability and financial stability.

Interviewees highlighted several current solutions in the construction industry, such as the government's mandate for projects over 10 million to use BIM, and efforts to continuously educate clients by showcasing successful BIM projects to demonstrate its value. Future solutions include the government providing financial incentives or tax reductions for companies adopting BIM, incorporating BIM into project design submissions, and developing industry-wide standardization. In summary, BIM adoption requires a push from clients, regulatory frameworks from the government, and clear requirements from bodies like CIDB, while technological providers should consider the preferences of the younger generation in their designs. These measures will collectively address the current barriers and accelerate the integration of BIM into the construction industry.

These findings clearly fulfill Research Objective 3, as they provide a comprehensive overview of actionable solutions that can enhance BIM adoption in Malaysia. The consistency between questionnaire and interview responses, combined with support from existing research, suggests that these solutions could effectively address the barriers previously identified. This analysis emphasizes the importance of cooperation, training, government support, and broader economic considerations in driving BIM adoption forward.

5.3 Research implication

The research highlights the need for academic institutions to adapt their program to better align with industry demands for BIM skills. Universities can improve their Computer Aided Quantity Surveying courses, introduce new programs focused on BIM integration with emerging technologies like AI, and offer short courses for upskilling. These changes will prepare the future workforce to meet the evolving needs of the construction industry, ensuring graduates are equipped with the practical knowledge required for BIM application.

The study provides valuable insights for construction professionals, particularly on the challenges hindering wider application of BIM and solutions to increase adoption. It highlights the importance of adopting BIM to improve project efficiency and outcomes, motivating firms to invest in BIM training and technology. Companies can use the research to refine their strategies for BIM application, helping them stay competitive and achieve better project results.

The findings from this research can help regulatory bodies, such as CIDB, develop more effective policies to support BIM adoption in the Malaysian construction industry. By understanding the challenges faced by companies, they can offer financial support like subsidies or tax breaks and establish guidelines to promote the use of BIM across projects of all sizes. This can accelerate the digital transformation in construction and ensure the industry aligns with global standards.

Software developers can leverage the findings to improve BIM software and its integration with AI, ensuring it meets the specific needs of the construction industry. Understanding the expectations of construction professionals allows developers to focus on creating user-friendly tools and offering better training and support, which can drive higher adoption rates of BIM technologies in the market.

The research provides valuable insights for policymakers to craft effective strategies that promote BIM and digital transformation in the construction sector. This includes creating supportive financial incentives, like low-interest loans or subsidies, and developing long-term digital transformation roadmaps. These efforts can enhance Malaysia's global competitiveness by driving broader adoption of BIM technologies.

In short, the implications of this research can be applied in practice by tailoring BIM adoption strategies to the specific needs of different industry segments. For large companies, government-mandated BIM use and standardized workflows can drive consistency and efficiency. In contrast, small and medium-sized enterprises (SMEs) may benefit more from targeted financial incentives, such as subsidies or low-cost training programs, to overcome cost-related barriers. Additionally, sectors with high technological integration, such as tech-driven firm can focus on BIM integration with AI and cloud-based platforms to further enhance project management and data-driven decision-making.

5.4 Research limitation

The study faced several challenges, including a short timeline of about nine months, with less than three months dedicated to data collection, limiting the sample size of BIM users in Malaysia. As an undergraduate, the researcher also struggled to access a broader range of BIM professionals, resulting in only 161 respondents. Additionally, the quantitative study was confined to the Klang Valley region, which may not fully represent BIM usage in other areas. Lastly, the findings are specific to the construction industry, meaning they may not apply to other sectors due to the unique challenges and practices within construction.

5.5 Research recommendation

To improve the research, the scope should be expanded to cover a broader geographical area across Malaysia, allowing for more precise results from a larger population. Extending the data collection period will provide a more comprehensive and diverse sample, ensuring more accurate and reliable conclusions. Engaging with more professionals, such as from CIDB, and increasing the number of respondents, especially from underrepresented groups, will strengthen the analysis. Additionally, leveraging online platforms and expert communities can offer valuable insights on the latest trends. Further investigation is needed to understand the perspectives of respondents at different management levels, like managers and directors, towards BIM. Lastly, exploring the integration of BIM with advanced technologies like digital twins and artificial intelligence could provide valuable insights into its future potential and application.

5.6 Summary of Chapter

In conclusion, this chapter summarizes the research findings and confirms that the research aims and objectives have been successfully achieved. The study's limitations are outlined, and appropriate recommendations are provided. Additionally, the contributions made by this research are highlighted at the end of the chapter.

REFERENCES

Afiq, A., 2020. Govt aims 80% adoption of BIM system by 2025. *The Malaysian Reserve.* [online] 30 Sept. Available at:< https://themalaysianreserve.com/2020/09/30/govt-aims-80-adoption-of-bim-system-by-2025/> [Accessed 7 September2024]

Ahlam, B.Q.A. and Abdul Rahim, Z.,2020. “A review of risks for BIM adoption in Malaysia construction industries: multi case study”, IOP Conference Series: Materials Science and Engineering, Vol. 1051, 012037, doi: 10.1088/1757-899X/1051/1/012037

Ahmed, Y, A., Shehzad, H, M, F., Khurshid, M, M., Hassan, O, H, A., Abdalla, S, A., Alrefai, N., 2022. *Examining the effect of interoperability factors on building information modelling (BIM) adoption in Malaysia.* [online] Available at:< https://www.emerald.com/insight/content/doi/10.1108/CI-12-2021-0245/full/pdf?title=examining-the-effect-of-interoperability-factors-on-building-information-modelling-bim-adoption-in-malaysia>[Accessed 5 October 2024]

Akmal, A, I., Nazareth, M, Y., Hamimah A., 2021. *BIM Adoption in Managing Construction Risks Amongst Malaysian Quantity Surveyors: Current Practice and Challenges.* [online] Available at:<https://publisher.uthm.edu.my/ojs/index.php/IJSCET/article/view/9746/4617 > [Accessed 7 September2024]

Allison, L., Gerard, G., 2024. All projects worth RM10mil and above to use construction software BIM, says Ahmad Maslan. *The Star.* [online] 4 Sept. Available at:<https://www.thestar.com.my/news/nation/2024/09/04/all-projects-worth-rm10mil-and-above-to-use-construction-software-bim-says-ahmad-maslan> [Accessed 6 September2024]

Ang, P, S, E., Pung, Y, L., Zulkaply, M, N, A., Tey, J, S., Kasim, N, B., Osman, M, H., Musa, M, K., Rahman, M, A, A., 2020. *BIM: The setback OR solution to project cost issues in Malaysia construction industry?* [online] Available at:< https://iopscience.iop.org/article/10.1088/1755-1315/476/1/012011/pdf> [Accessed 6 October 2024]

Ariono, B., Wasesa, M., Dhewanto, W., 2022. The Drivers, Barriers, and Enablers of Building Information Modeling (BIM) Innovation in Developing Countries: Insights from Systematic Literature Review and Comparative Analysis. [online] Available at:< https://www.mdpi.com/2075-5309/12/11/1912> [Accessed 5 October 2024]

Aris, R, N, B., 2024. JKR implements BIM technology in 455 construction projects. *The Edge Malaysia.* [online] 28 Aug. Available at:<https://theedgemalaysia.com/node/724693> [Accessed 6 September2024]

Ashmori, Y, Y, A., Othman, I., Aidrous, A, H, M, H, A., 2023. *Values, Challenges, and Critical Success Factors" of Building Information Modelling (BIM) in Malaysia: Experts Perspective.* [online] Available at:< https://www.mdpi.com/2071-1050/14/6/3192> [Accessed 3 April 2024]

Ashmori, Y, Y., Othman, I., Rahmawati, Y., Amran, Y, H, M., Sabah, S, H, A., Rafindadi, A, D., Mikic, M., 2020. *BIM benefits and its influence on the BIM implementation in Malaysia.* [online]. Available at:< https://www.sciencedirect.com/science/article/pii/S2090447920300344?via%3Dihub> [Accessed 3 October 2024].

Baharom, M, H., Habib, S, N, H, A., and Ismail, S., 2021. *Building Information Modelling (BIM): Contractual Issues of Intellectual Property Rights (IPR) in Construction Projects.* [online] Available at:< https://www.researchgate.net/publication/351821160_Building_Information_Modelling_BIM_Contractual_Issues_of_Intellectual_Property_Rights_IPR_in_Construction_Projects> [Accessed 6 October 2024]

Banawi, A., 2017. Understanding Building Information Modeling (BIM) implementation in developing countries: A case study from the Saudi Arabian construction industry. Journal of Engineering, Design and Technology, 15(3), 335-351.

Barnes, P., and Davies, N. (2014). BIM in Principle and in Practice.

Bayhan, H.G., Demirkesen, S., Zhang, C. and Tezel, A., 2021. "A lean construction and BIM interaction model for the construction industry", Production Planning and Control, pp. 1-28, doi: 10.1080/ 09537287.2021.2019342.

BIM Africa, 2020. *"Africa BIM report 2020"* [online] Available at: <www.researchgate.net/publication/ 344197161_African_BIM_Report_2020> [Accessed 4 April 2024]

Brahim, J., Latiffi, A, A., Fathi, M, S., 2018. *APPLICATION OF BUILDING INFORMATION MODELLING (BIM) IN DESIGN AND BUILD (D&B) PROJECTS IN MALAYSIA.* [online] Available at:< https://library.ucyp.edu.my/wp-content/uploads/2023/01/Application-of-Building-Information-Modelling-BIM-in-Design-and-Build-DB-projects-in-Malaysia-2018.pdf>[Accessed 6 October 2024]

Bonanomi, M., 2016. Building Information Modeling (BIM) and Facility Management (FM) Knowledge Management and Information Tools for Building Maintenance and Facility Management (pp. 149-177): Springer.

Braun V., Clarke V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://www.tandfonline.com/doi/abs/10.1191/1478088706qp063oa.

Cambridge Dictionary, 2024. *Application.* [online] Available at:< https://dictionary.cambridge.org/dictionary/english/application> [Accessed 5 October 2024].

CIDB,2016. ‘‘Construction Industry Transformation Programme (CITP) 2016-2020,” Construction Industry Development Board Malaysia.

Chan, J, R., Sadeghifam, A, N., Jon, M, S., 2022. The Barrier Factors to the Implementation of Building Information Modelling for Construction Industry in Sarawak. [online]. Available at: <https://doi.org/10.53623/csue.v2i1.86> [Accessed 25 March 2024]

Chuah, P, L., 2024. *Building Information Modelling, 2024.* [online]. Available at:<https://issuu.com/the_institution_of_engineers_malaysia/docs/jurutera_may24_low_res/30> [Accessed 2 October 2024]

CIDB, 2019. *CIDB Technical Report, Publication No.208.* [online] Available at:<https://www.cidb.gov.my/wp-content/uploads/2022/07/208-Malaysia-BIM-REPORT-2019-min.pdf> [Accessed 25 March 2024]

CIDB, 2020. BIM Concept & Theory – Online Course. Retrieved October 22, 2020, from CIDB website: https://mybim.cidb.gov.my/product/bim-concept-theory-online-course/

CIDB, 2021. *Malaysia Building Information Modelling (BIM) Report 2021.* [online]. Available at:<https://smart.cidb.gov.my/publication/malaysia-building-information-modelling-bim-report-2021-457> [Accessed 2 October 2024].

CIDB, 2022. *BIM in Malaysia (A Constructive Journey).* [online]. Available at:<https://smart.cidb.gov.my/article/bim-in-malaysia-a-constructive-journey-41> [Accessed 2 October 2024]

CIDB, 2023. *The Barrier Factors of the Readiness Implementation of Building Information Modelling (BIM) for Interior design Industry in Construction Stage.* [online]. Available at:<https://smart.cidb.gov.my/article/the-barrier-factors-of-the-readiness-implementation-of-building-information-modelling-bim-for-interior-esign-industry-in-construction-stage-395> [Accessed 2 October 2024]

Cochran, W. G. (1977). Sampling techniques. 3rd Ed. New York: John Wiley & Sons.

Creswell, J. W., 1999. Mixed method research: Introduction and application. In T. Cijek (Ed.), Handbook of educational policy (pp. 455–472). San Diego, CA: Academic Press.

Creswell, J.,1998. *Qualitative Inquiry and Research Design: Choosing Among Five Traditions*. California, United States of America: SAGE Publications, Inc.

Creswell, J, W., Creswell, J, D., 2023. *Research Design. Qualitative, Quantitative and Mixed Methods Approaches.* United Kingdom. Sage Publications.

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E., 2004. An expanded typology for classifying mixed methods research into designs. A. Tashakkori y C. Teddlie, Handbook of mixed methods in social and behavioral research, 209-240.

Demirkesen, S. and Tezel, A., 2022. Investigating major challenges for industry 4.0 adoption among construction companies. *Engineering, Construction and Architectural Management*, [e-journal] 29(3), pp.1470-1503. https://doi.org/10.1108/ECAM-12-2020-1059.

Deshpande, A. and Whitman, J. B. (2014) "Evaluation of the use of BIM tools for construction site utilization planning", in the 50th ASC Annual International Conference, Virginia

Eadie, R., Browne, M., Odeyinka, H., McKeown, C., and McNiff, S. (2015). A survey of current status of and perceived changes required for BIM adoption in the UK. Built Environment Project and Asset Management, 5(1), 4-21.

Economic Planning Unit, 2021. *Twelve Malaysian Plan, 2021-2025.* [online]. Available at:<https://faolex.fao.org/docs/pdf/mal210617.pdf> [Accessed 2 October 2024]

E. Kamel, A.M. Memari, Review of BIM's application in energy simulation: tools, issues, and solutions, Autom. Constr. 97 (2019) 164–180, https://doi.org/10. 1016/j.autcon.2018.11.008.

Enegbuma, W., et al., 2014. Challenges to the adoption of Building Information Modelling in the Malaysian construction industry. International Journal of Construction Engineering and Management, 3(6), 197-206.

Enshassi, A., AbuHamra, L. A. and Alkilani, S. (2018) "Studying the benefits of building information modeling (BIM) in architecture, engineering and construction (AEC) industry in the Gaza strip", Jordan Journal of Civil Engineering, Vol. 12, No. 1, pp. 87–98

Feng, N.T., 2021. "Implementation of BIM in residential building in Malaysia", Final Year Project (Bachelor), Tunku Abdul Rahman University College

Gamel, Y., Rahman, I., 2019. Awareness and challenges of building information modelling (BIM) implementation in the Yemen construction industry. [online]. Available at:< https://www.emerald.com/insight/content/doi/10.1108/JEDT-03-2019-0063/full/html> [Accessed 28 February 2024]

Guest, G., Bunce, A., & Johnson, J. (2006). *How Many Interviews Are Enough? An Experiment with Data Saturation and Variability*. SAGE Journals, 59-82.

Hamil, S., 2021. *What is BIM?* [online]. Available at:< https://www.thenbs.com/knowledge/what-is-building-information-modelling-bim> [Accessed 2 October 2024]

Hamil, 2018. *What is COBie?* [online] Available at:< https://www.thenbs.com/knowledge/what-is-cobie> [Accessed 6 October 2024]

Hardin, B., and McCool, D., 2015. BIM and construction management: proven tools, methods, and workflows: John Wiley & Sons.

Hussain, C, M., Nuzhat,S., 2022. *Source reduction and waste minimization in construction industry.* [Online] Available at:<https://www.sciencedirect.com/topics/earth-and-planetary-sciences/construction-industry#:~:text=Construction%20industry%20refers%20to%20the,%2C%20renovating%2C%20and%20maintaining%20infrastructures> [Accessed 18 March 2024]

Ibrahim, F, S., Rahman, R, A., 2019. *The Barriers Factors and Driving Forces for Bim Implementation in Malaysian Aec Companies.* [online] Available at:< https://www.researchgate.net/profile/Farah-Ibrahim/publication/335338628_THE_BARRIERS_FACTORS_AND_DRIVING_FORCES_FOR_BIM_IMPLEMENTATION_IN_MALAYSIAN_AEC_COMPANIES/links/5d5f848b45851521025a1cf6/THE-BARRIERS-FACTORS-AND-DRIVING-FORCES-FOR-BIM-IMPLEMENTATION-IN-MALAYSIAN-AEC-COMPANIES.pdf> [Accessed 25 March 2024]

Ibtisam, A,M,Y., Faizul, A.M.R., Nurshuhada, Z., 2018. *Risk in Implementing Building Information Modelling (BIM) in Malaysia Construction Industry: A Review.* [online] Available at: <https://doi.org/10.1051/e3sconf/20186503002> [Accessed 18 March 2024]

Idris Othman a, Y. Y. A.-A. a. ,. Y. R. a. ,. Y. M. A. b. ,. M. A. M. A.-B., 2020. The level of Building Information Modelling (BIM) Implementation in Malaysia. Ain Shams Engineering Journal, 12(2021), p. 463.

Ilhan B, Yaman H. Meta-Analysis of Building Information Modeling Literature in Construction. Int. J. Eng. Innov. Technol. 2013;3(4):373–9.

In Liu, S. Z., Javed, A. A., Ni, F. D. and Shen, A. W. (Ed). Faculty of Construction and Land Use, The Hong Kong Polytechnic University. Vol 1. pp. 399-407. 11th – 12th July, Hong Kong. https://www.researchgate.net/profile/Wallace-Enegbuma/publication/262805256_A_PRELIMINARY_STUDY_ON_BUILDING_INFORMATION_MODELLING_BIM_IMPLEMENTATION_IN_MALAYSIA/links/5440e8d20cf2ebb0369041f6/A-PRELIMINARY-STUDY-ON-BUILDING-INFORMATION-MODELLING-BIM-IMPLEMENTATION-IN-MALAYSIA.pdf

Isaac, O, E., 2023. *Convenience and Purposive Sampling Techniques: Are they the Same?* [online] Available at :< https://seahipaj.org/journals-ci/mar-2023/IJISSER/full/IJISSER-M-1-2023.pdf> [Accessed 1 April 2024]

Ismail, N, A, A., Yousof, M, N, M., Adnan, H., 2021. *BIM Adoption in Managing Construction Risks Amongst Malaysian Quantity Surveyors: Current Practice and Challenges.* [online] Available at:< https://publisher.uthm.edu.my/ojs/index.php/IJSCET/article/view/9746/4617> [Accessed 4 October 2024]

ISO,2024. *Abstract.* [online] Available at:<https://www.iso.org/standard/70303.html> [Accessed 6 October 2024]

Jack, C.P. Cheng., and Qiqi, Lu, M.Phil., 2015. A Review of The Efforts and Roles of The Public Sector For Bim Adoption Worldwide. [online] Available at:<https://itcon.org/papers/2015_27.content.01088.pdf > [Accessed 28 February 2024]

Jamal, K,A,A., Mohammad, M, F., Hashim, N., Mohamed, M, R., and Ramli, M, A., 2019. *Challenges of Building Information Modelling (BIM) from the Malaysian Architect's Perspective.* [online] Available at:< https://doi.org/10.1051/matecconf/2019 *I 2018* **266** 2660 03> [Accessed 18 March 2024]

Jamaludin, S, Z, H, S., Ismail, N, A, A., Ibrahim, I, H, Japlun, N., 2022. *The Emerging Challenges of Adopting BIM in the Construction Industry: Evidence from Sabah, Malaysia.* [online] Available at:< https://ir.uitm.edu.my/id/eprint/10125/1/10125.pdf> [Accessed 25 March 2024]
K.F. Chien, Z.H. Wu, S.C. Huang, Identifying and assessing critical risk factors for BIM projects: Empirical study, Auto. in Cons. 45, 1-15 (2014)

JKR, 2019. *BIM 101: A CONCISE INTRODUCTION TO BUILDING INFORMATION MODELING.* [online] Available at:<https://www.jkr.gov.my/sites/default/files/upload/2019-03-05a_BIM%20POCKET%20BOOK.pdf> [Accessed 5 October 2024]

Kensek, K. M., 2014. Building information modeling: Routledge.

Kermanshahi, E, K., Lim, N, H, A, S., Balasbaneh, A, T., Tahir, M, B, M., 2020. *Implementation of Building Information Modeling for Construction Clash Detection Process in the Design Stage: A Case Study of Malaysian Police Headquarter Building.* [online] Available at:< https://www.researchgate.net/publication/342107928_Implementation_of_Building_Information_Modeling_for_Construction_Clash_Detection_Process_in_the_Design_Stage_A_Case_Study_of_Malaysian_Police_Headquarter_Building> [Accessed 6 October 2024]

Khosrowshahi, F. (2017) Building Information Modelling (BIM) a Paradigm Shift in Construction. In: Dastbaz, M., Gorse, C. and Moncaster, A. (eds.)

Building Information Modelling, Building Performance, Design and Smart Construction, Springer, Cham

Kjartansdóttir, I, B., Mordue, S., Nowak, P., Philp, D., Snæbjörnsson, J, T., 2017. *Building Information Modelling – BIM.* [online] Available at:< https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.ciob.org/sites/default/files/M21%2520%2520BUILDING%2520INFORMATION%2520MODELLING%2520-%2520BIM.pdf&ved=2ahUKEwj2gZSFr_KIAxV9zDgGHW4OBksQFnoECCgQAQ&usg=AOvVaw2EuO9pNjs-KcPVxbsOl3No> [Accessed 3 October 2024].

Kong, S, W, R., Lau, L, T., Wong, S, Y., and Phan, D, T., 2020. A study on effectiveness of Building Information Modelling (BIM) on the Malaysian construction industry. https://iopscience.iop.org/article/10.1088/1757-899X/713/1/012035/meta

Latiffi, A., Mohd, S., Kasim, N. and Fathi, M., 2013. Building Information Modeling (BIM) Application in Malaysian Construction Industry. [pdf] Available at:<https://www.researchgate.net/publication/256605769_Building_Information_Modeling_BIM_Application_in_Malaysian_Construction_Industry>[Accessed 9 September 2024]

Latiffi, A. A., Mohd, S. and Rakiman, U. S., 2016. "Potential improvement of building information modeling (bim) implementation in Malaysian construction projects", In the 12th IFIP International Conference on Product Lifecycle Management, Doha.

Latiffi, A., Brahim, J. and Fathi, M. S. (2016). Transformation of Malaysian Construction Industry with Building Information Modelling (BIM). Paper presented at the MATEC Web of Conferences. EDP Sciences. pp. 00022.

Manzoor, B., Othman, I., Gardezi, S, S, S., Harirchian, E., 2021. *Strategies for Adopting Building Information Modeling (BIM) in Sustainable Building Projects—A Case of Malaysia.* [online] Available at:< https://www.mdpi.com/2075-5309/11/6/249> [Accessed 1 April 2024]

Matarneh, R. and Hamed, S. (2017), "Barriers to the adoption of building information modeling in the Jordanian building industry", Open Journal of Civil Engineering, Vol. 7, pp. 325-335.

Memon AH, Rahman IA, Memon I, Azman NIA. BIM in Malaysian construction industry: Status, advantages, barriers and strategies to enhance the implementation level. Res. J. Appl. Sci. Eng. Technol. 2014;8(5):606–614.

Miza, R, M, S., Tee, T, K., Nazir, N, A., 2023. *Readiness and Challenges of the Construction Industry in Implementing Building Information Modelling (BIM).* [online]. Available at:<https://publisher.uthm.edu.my/ojs/index.php/JTET/article/view/13501/5641> [Accessed 2 October 2024].

Mustaffa, E., Salleh,R., and Liyana, H., 2017. Experiences of Building Information Modelling (BIM) Adoption in Various Countries. [online] Available at:<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8002508> [Accessed 28 February 2024]

Mustapa, S, A, H, S., Jamaluddin, N, A., 2022. *Awareness Level and Challenges of Building Information Modelling (BIM) Implementation among Quantity Surveying Profession.* [online] Available at:< https://hrmars.com/papers_submitted/15069/awareness-level-and-challenges-of-building-information-modelling-bim-implementation-among-quantity-surveying-profession.pdf> [Accessed 6 October 2024]

Naing, T, M., Sadeghifma, A, N., Joo, M, S., 2022. *Identifying the Critical Barriers Factors to the Implementation of Building Information Modelling (BIM) in the Sarawak's Construction Industry.* [online] Available at: <https://doi.org/10.53623/csue.v2i1.83> [Accessed 25 March 2024]

NBS, 2020. 10th Annual BIM Report 2020, Retrieved from Newcastle upon Tyne, UK

Omar, F., Fateh, M, A, M., 2023. *COST BENEFIT ANALYSIS (CBA) IN BUILDING INFORMATION MODELLING (BIM) APPLICATION IN GOVERNMENT HEALTHCARE FACILITIES PROJECTS IN MALAYSIA.* [online] Available at:< https://www.planningmalaysia.org/index.php/pmj/article/view/1257/939> [Accessed 6 October 2024]

Omar, F., Fateh, M, A,M., Godawatte, G, A, G, R., 2023. *Critical Success Factors (CFSs) Implementation Cost-Benefit Analysis (CBA) Into Building Information Modelling (BIM) Application Through Malaysian Government Healthcare Projects.* [online] Available at:< https://pure.hw.ac.uk/ws/portalfiles/portal/104159177/document.pdf> [Accessed 6 October 2024]

Onungwa, I., & Uduma-Olugu, N., 2016. Building Information Modeling (BIM): Benefits, risks and challenges. American Journal of Civil Engineering and Architecture, 4(5), 158-167.

Othman, I., Al-Ashmori, Y.Y., Rahmawati, Y., Amran, Y.H.Y.H.M. and Al-Bared, M.A.M., 2021. “The level of building information modelling (BIM) implementation in Malaysia”, Ain Shams Engineering Journal, Vol. 12, pp. 455-463.

Preidel, C., Borrmann, A., Mattern, H., Konig, M., Schapke, S, E., 2018. *Common Data Environment.* [online] Available at:< https://www.researchgate.net/publication/327760132_Common_Data_Environment#:~:text=Environment%20(CDE).-,The%20CDE,for%20sharing%20and%20approval%20processes.> [Accessed 6 October 2024]

Progress, A., Said, A., and Abbas, 2018. *Cloud-Based Project Management: Collaborating and Tracking.* [online] Available at:< https://www.researchgate.net/publication/372763094_Cloud-Based_Project_Management_Collaborating_and_Tracking> [Accessed 6 October 2024]

R. Sacks, C. Eastman, G. Lee, and P. Teicholz, BIM Handbook RafaelSacks, vol. 25, no. 2. 2018.

Radman, K., Jelodar, M, B., Ghazizadeh, E., Wilkinson, S., 2021. *Causes of Delay in Smart andComplex Construction Projects*. [online] Available at:< https://ascelibrary.org/doi/epdf/10.1061/%28ASCE%29LA.1943-4170.0000501> [Accessed 6 October 2024]

Rahim, S., Nifa, F. A. A., and Navi, M. N. M., ‘‘Integrated Project Delivery (IPD) in Malaysian Construction Industry Dealing with Waste Issue,” no. January, 2015.

Rajendran, P., Gomez, C, P., 2012. *Implementing BIM for waste minimization in the construction industry: a literature review*. 2nd international conference on Management, Malaysia.

Rane, Nitin., 2023. Integrating Building Information Modelling (BIM) and Artificial Intelligence (AI) for Smart Construction Schedule, Cost, Quality, and Safety Management: Challenges and Opportunities. http://dx.doi.org/10.2139/ssrn.4616055

Raza, M, S., Tayeh, B, A., Aisheh, Y, I, A., Maglad, A, M., 2023. [online] Available at:<https://www.sciencedirect.com/science/article/pii/S2405844023069050> [Accessed 6 October 2024]

Richard, M., 2014. *BIM Levels explained.* [online] Available at:<https://www.thenbs.com/knowledge/bim-levels-explained> [Accessed 6 September2024]

RICS, 2020. *The role of technology in working through a pandemic.* [online]. Available at:<https://www.rics.org/news-insights/the-role-of-technology-in-working-through-a-pandemic> [Accessed 2 October 2024]

RICS, 2022. *The future of BIM.* [online] Available at:< https://www.rics.org/news-insights/the-future-of-bim#:~:text=Building%20Information%20Modelling%20(BIM)%20is,process%20of%20a%20building%20project.> [Accessed 6 October 2024]

Roseli, F, A., Abas, N, H., Ibrahim, N, Q., Taat, N, H, M., 2024. *BARRIERS OF BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION: CURRENT PERSPECTIVES OF CONSTRUCTION STAKEHOLDERS IN JOHOR, MALAYSIA.* [online] Available at:<

https://publisher.unimas.my/ojs/index.php/JCEST/article/view/5771> [Accessed 6 October 2024]

Roslan, A, F., Hamid, Z, A., Zain, M, Z, M., Kilau, N, M., Dzulkalnine, N., Hussain, A, H., 2019. *BUILDING INFORMATION MODELLING (BIM) STAGE 2 IMPLEMENTATION STRATEGY FOR THE CONSTRUCTION INDUSTRY IN MALAYSIA.* [online] Available at: < https://www.researchgate.net/profile/Ainul-Noruzman/publication/339139736_Clean_Strength_Leaching_and_Microstructure_of_Polymer_Modified_Concrete_Incorporating_Vinyl_Acetate_Effluents/links/5ece1fe792851c9c5e5f78b2/Clean-Strength-Leaching-and-Microstructure-of-Polymer-Modified-Concrete-Incorporating-Vinyl-Acetate-Effluents.pdf#page=165>[Accessed 25 March 2024]

Rui, Wah, Siang, 2021. *Construction Project Management Based on Building Information Modeling (BIM).* [online] Available at:< https://eprints.utm.my/94854/1/YinRui2021_ConstructionProjectManagementBased.pdf> [Accessed 6 October 2024]

Sacks, R., Eastman, C., Lee, G., Teicholz, P., 2018. *BIM Handbook.* [online] Available at:< https://books.google.com.my/books?hl=en&lr=&id=IU9mDwAAQBAJ&oi=fnd&pg=PR18&dq=building+information+modelling+concept&ots=NgiwEw4sCJ&sig=Z5azoeYzlaRzpCWMDohFqN_foLU&redir_esc=y#v=onepage&q=building%20information%20modelling%20concept&f=false> [Accessed 6 October 2024]

Saka, A., & Chan, D. W. M., 2019b. A global review of Building Information Modelling (BIM) research trends in the construction industry. Automation in Construction, 103, 38-52.

Sepasgozar, S.M., Hui, F.K.P., Shirowzhan, S., Foroozanfar, M., Yang, L. and Aye, L., 2021. “Lean practices using Building Information Modeling (BIM) and digital twinning for sustainable construction”, Sustainability, Vol. 13 No. 1, p. 161, doi: 10.3390/su13010161

Sharen, K., 2024. Building Information Modelling mandate set to transform construction industry. *Business Times.* [online] 20 June. Available at:< https://www.nst.com.my/business/corporate/2024/06/1065832/building-information-modelling-mandate-set-transform-construction> [Accessed 6 September2024]

Shehzad, H, M, F., Ibrahim, R,B., Yusof,A,F., Khaidzir, K, A, M., Iqbal,M., Razzaq,S., 2021. *The role of interoperability dimensions in building information modelling, Computers in Industry*, Volume 129, 103444, ISSN 0166-3615, https://doi.org/10.1016/j.compind.2021.103444.

Shojaei, R.S. and Burgess, G., 2022. Non-technical inhibitors: Exploring the adoption of digital innovation in the UK construction industry. Technological

Forecasting and Social Change, [e-journal] 185, pp.1-13. https://doi.org/10.1016/j.techfore.2022.122036.

Sinenko, S., Hanitsch, P., Aliev, S., Volovik, M., 2020. *The implementation of BIM in construction project.* [online] Available at:< https://www.researchgate.net/publication/341156449_The_implementation_of_BIM_in_construction_projects> [Accessed 6 October 2024]

Sinoh, S, S., Ibrahim, Z., Othman, F., Muhammad, N, L, N., 2020. *Review of BIM literature and government initiatives to promote BIM in Malaysia.* [online] Available at:< https://iopscience.iop.org/article/10.1088/1757-899X/943/1/012057/pdf> [Accessed 2 April 2024]

Song, H., Yang, G., Li, H., Zhang, T., Jiang, A., 2023. *Digital twin enhanced BIM to shape full life cycle digital transformation for bridge engineering.* [online]. Available at:<https://www.sciencedirect.com/science/article/abs/pii/S0926580522006069> [Accessed 2 October 2024]

S. Paneru, P. Ghimire, A. Kandel, S. Thapa, N. Koirala, M. Karki, An exploratory investigation of implementation of building information modeling in Nepalese architecture–engineering–construction industry [article], Buildings 13 (2) (2023), https://doi.org/10.3390/buildings13020552. Article 552.

Sriyolja, Z., Harwin, N., Yahya, K., 2021. Barriers to Implement Building Information Modeling (BIM) in Construction Industry: A Critical Review. [online] Available at: < https://iopscience.iop.org/article/10.1088/1755-1315/738/1/012021/pdf> [Accessed 4 April 2024]

Taherdoost, H., 2022. *What are Different Research Approaches? Comprehensive Review of Qualitative, Quantitative, and Mixed Method Research, Their Applications, Types, and Limitation.* [online]. Available at:<https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4178694> [Accessed 30 March 2024].

Tan, T.; Chen, K.; Xue, F.; Lu, W., 2019. Barriers to Building Information Modeling (BIM) implementation in China’s prefabricated construction: An interpretive structural modeling (ISM) approach. *Journal of Cleaner Production, 219*, 949–959. https://doi.org/10.1016/j.jclepro.2019.02.141

The Institution of Structural Engineers, 2021. *An introduction to Building Information Modelling (BIM).* [online] Available at:< https://www.istructe.org/IStructE/media/Public/An_introduction_to-Building_Information_Modelling_BIM.pdf> [Accessed 4 October 2024]

The Malaysia Building Information Modelling (BIM) Report, 2016. [online]. Available at: <https://mybim.cidb.gov.my/download/malaysia-bim-report-2016/#>. [Accessed 30 March 2024].

The University of Newcastle, 2023. *Research Methods: What are research methods?* [online]. Available at:< https://libguides.newcastle.edu.au/researchmethods#:~:text=Research%20methods%20are%20the%20strategies,different%20tools%20for%20data%20collection.> [Accessed 30 March 2024].

Tsai, M, H., Chen, K, L., Chang, Y, L., 2019. Development of a Project-Based Online Course for BIM Learning. [online] Available at:< https://www.mdpi.com/2071-1050/11/20/5772> [Accessed 6 October 2024]

Uakarn, C., Chaokromthong, K., Sintao, N., 2021. *Sample Size Estimation using Yamane and Cochran and Krejcie and Morgan and Green Formulas and Cohen Statistical Power Analysis by G*Power and Comparisons.* [online] Available at<https://www.studocu.com/ph/document/rizal-technological-university/bs-psychology/numaamati07-full-pdf/42038724> [Accessed 4 October 2024].

Ullah, K.,Lill, I., Witt,E., 2019. An Overview of BIM Adoption in the Construction Industry; Benefits and Barriers. https://www.emerald.com/insight/content/doi/10.1108/S2516-285320190000002052/full/html

Umar, T., 2022. "Challenges of BIM implementation in GCC construction industry", Engineering, Construction and Architectural Management, Vol. 29 No. 3, pp. 1139-1168. https://doi.org/10.1108/ECAM-11-2019-0608

Usman, M. A., 2015. Exploring critical success factors for building information modeling (BIM) implementation in the Nigerian construction industry. Engineering, Construction and Architectural Management, 22(5), 548-567.

Wong, J, H., Rashidi, A., Arashpour, M., 2020. *Evaluating the Impact of Building Information Modeling on the Labor Productivity of Construction Projects in Malaysia.* [online] Available at:< https://www.mdpi.com/2075-5309/10/4/66> [Accessed 6 October 2024]

Yaacob, M, R., Isa, C, M, M., Rahman, S, H, A., Salleh, S., 2024. *BARRIERS TO BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION AMONG CIVIL AND STRUCTURAL CONSULTANTS IN MALAYSIA'S CONSTRUCTION INDUSTRY.* [online] Available at:<https://gaexcellence.com/ijirev/article/view/1056/797> [Accessed 6 October 2024]

Vidalakis, C., Abanda, F.H. and Oti, A.H., 2020, "BIM adoption and implementation: focusing on SMEs", Construction Innovation, Vol. 20 No. 1, pp. 128-147. https://doi.org/10.1108/CI-09-2018-0076

Waqar, A., Qureshi, A.H. and Alaloul, W.S., 2023. Barriers to Building Information Modelling (BIM) deployment in small construction projects: Malaysian construction industry. Sustainability (Switzerland), [e-journal] 15(3), pp.1-30. https://doi.org/10.3390/su15032477

Wong,C,F., Lau,F,H., Tan,O,K., Yap,B,H., 2023. the adoption of building information modelling (BIM) using technological adoption framework and structural equation modelling https://www.emerald.com/insight/content/doi/10.1108/ECAM-06-2023-0637/full/html

Wong, S, Y., Gray, J., 2019. *Barriers to implementing Building Information Modelling (BIM) in the Malaysian construction industry.* [online] Available at: <https://iopscience.iop.org/article/10.1088/1757-899X/495/1/012002/pdf> [Accessed 20 March 2024]

Yan, Kah, 2018. *BUILDING INFORMATION MODELLING (BIM) IN SMALL AND MEDIUM ENTERPRISES (SMES) WITHIN MALAYSIAN CONSTRUCTION SECTOR: IMPLEMENTATION, BARRIERS, AND SOLUTIONS.* [online] Available at:< http://eprints.intimal.edu.my/1333/1/vol2_2018_1.pdf> [Accessed 6 October 2024]

Yasser, A., Idris, O., Hisham, M., Madzlan, N., 2019. *Establishing the Level of BIM implementation – A Case Study in Melaka, Malaysia.* [online]. Available at:<https://www.researchgate.net/publication/335591946_Establishing_the_Level_of_BIM_implementation_-_A_Case_Study_in_Melaka_Malaysia> [Accessed 2 October 2024]

Yan, Kah, 2018. *BUILDING INFORMATION MODELLING (BIM) IN SMALL AND MEDIUM ENTERPRISES (SMES) WITHIN MALAYSIAN CONSTRUCTION SECTOR: IMPLEMENTATION, BARRIERS, AND SOLUTIONS.* [online] Available at:< http://eprints.intimal.edu.my/1333/1/vol2_2018_1.pdf> [Accessed 6 October 2024]

Zahedi, F., Sardroud, J, M., Kazemi, S., 2022. Global BIM Adoption Movements and Challenges: An Extensive Literature Review. [online]. Available at:< https://www.researchgate.net/profile/Foad-Zahedi/publication/367538605_Global_BIM_Adoption_Movements_and_Challenges_An_Extensive_Literature_Review/links/641d5035a1b72772e4229188/Global-BIM-Adoption-Movements-and-Challenges-An-Extensive-Literature-Review.pdf> [Accessed 3 April 2024]

Zainon, N., Mohd-Rahim, F.A, Aziz, N.M., Kamaruzzaman, S.N. and Puidin, S. (2018) Catching Up with BuildingInformation Modeling: Challenges And Opportunities For Quantity Surveyors. Journal of Surveying, Construction and Property (JSCP), Volume 9, Issue 1.

Zhan, Z., Tang, Y., Wang, C., Yap, J.B.H. and Lim, Y.S.,2022. "System dynamics outlook on BIM and LEAN interaction in construction quantity surveying", Iranian Journal of Science and Technology, Transactions of Civil Engineering, pp. 1-16, doi: 10.1007/s40996-022-00833-w

Zulkefli, N, S., Rahim, F, A., Zainon, N., 2020. *Integrating Building Information Modelling (BIM) and Sustainability to Greening Existing Building: Potentials in Malaysian Construction Industry*. [online] Available at:< https://penerbit.uthm.edu.my/ojs/index.php/IJSCET/article/view/7725/3972> [Accessed 4 April 2024]

Zulkifli, M, Z, A., Mos, M, T, A., Mahat, N., Jasni, M, D., Khamaksorn, A., Malek, M, I, A., 2024. *Review of Building Information Modeling (BIM) Adoption Amongst SMEs in the Malaysian Construction Industry*. [online] Available at:< https://hrmars.com/papers_submitted/22219/review-of-building-information-modeling-bim-adoption-amongst-smes-in-the-malaysian-construction-industry.pdf> [Accessed 6 October 2024]

APPENDICES

Appendix A: Interview Question Sample

Interview questions

Title: EXPLORE BUILDING INFORMATION MODELLING (BIM) APPLICATION AND PERFORMANCE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Objectives:

1. To examine the current implementation stage of BIM in the Malaysian construction industry
2. To investigate barriers hindering the process of BIM implementation in the Malaysian construction industry
3. To identify solutions to increase the adoption of BIM in the Malaysian construction industry

Please provide the following information for record purpose, thank you.

- Profession:
- Job Title:
- Years in Construction Industry:
- Years of Using BIM Software:
- Company Background:

1. **BIM Perception:**

- What is your **personal view** on the current state of BIM adoption in the Malaysian construction industry, particularly within JKR projects?

- From your perspective, how **effective** are the current BIM standard guidelines and procedures for JKR projects? Are there any areas you see needing improvement?

2. **BIM Practices:**

- What is the **BIM software** that you are currently using? What specific features/applications of BIM have you found **most valuable** in your past projects, or what do you anticipate will be most beneficial in the future?

- Briefly describe **JKR's current level of BIM adoption**. How does it vary across different project types?

- Can you share a **specific example** of a successful BIM implementation within a JKR project? What factors contributed to its success, and what lessons were learned?

3. BIM Challenges:

- In your opinion, what are the **top 3 challenges** hindering wider implementation in Malaysia construction industry? Can you elaborate more on it?

- When working on BIM projects, what are some of the **biggest challenges** you face in terms of **collaboration with other stakeholders** (architects, engineers, etc.)? How do you overcome these challenges?

- What are the **biggest challenges** JKR faces in promoting wider BIM adoption **compared to private sector**? Why?

4. BIM Solutions:

- In your opinion, what **improvements** would make BIM more attractive for wider adoption in the Malaysian construction industry?

- How does BIM adoption and implementation in Malaysia **compare to other countries** you are familiar with? Are there best practices from other regions that could be **applied in Malaysia**?

- How do you see the **role of government** evolving in supporting and mandating BIM use in the Malaysian construction industry?

5. Future plans:

- Are there any **plans** to **further expand BIM adoption** within JKR, and if so, what specific strategies are being considered?

- In your opinion, what are the **key trends** that will shape the future of BIM adoption in Malaysia over the next 5-10 years?

- Do you think **BIM will become a norm** or organizational culture in the Malaysian construction industry in the future? Why?

Appendix B: Interview Transcript Sample

Theme 1: BIM Perception

Q1: What is your personal view on the current state of BIM adoption in the Malaysian construction industry?

A: *"There is growing awareness and adoption of BIM in the Malaysian construction industry compared to 5-10 years ago. More projects are now using BIM. My company uses Autodesk Revit for BIM, starting around 2-3 years ago. They primarily use it for clash detection between architectural, structural, and MEP drawings. The main benefit they have found is being able to identify and resolve clashes earlier in the design process, reducing rework."*

Theme 2: BIM Practices

Q1: Can you share a specific example of a project where your company used BIM?

A: *"The company is using BIM on a high-rise residential project with two 56-story towers. They use BIM primarily for coordination and clash detection between the architectural, structural, and MEP disciplines. This allows them to identify and resolve clashes earlier in the design process. For example, they can use BIM to determine the exact clearance heights required for the car park and driveway and identify if they can achieve the necessary clearance based on the design. This helps avoid costly rework later on."*

Q2: So, does your company follow any specific standard or protocols? How do these standards contribute to efficient collaboration and also the data exchange?

A: *"The standards and guidelines they follow are roughly the same as for traditional 2D projects, with the main difference being the 3D modelling. They still need to get the same approvals and conduct the same coordination process, just in a 3D environment instead of 2D."*

Q3: What are some of the challenges you face in terms of collaboration with other stakeholders such as an architect, an engineer, how do you address these challenges?

A: *"The main challenge is that the BIM software like Revit and Navisworks require high-spec computers with good graphics cards to run smoothly. Not all computers can support the software, so they need to ensure they have access to high-performance hardware to use the BIM tools effectively."*

Q4: In your opinion, what are the top three challenges that hindering by the implementation of BIM software being in the Malaysian construction industry?

A: *"Key challenges hindering BIM adoption are the high cost of software and lack of BIM specialists in the industry, as well as a lack of clear BIM guidelines from authorities."*

Q5: So, based on that, what improvement can make BIM higher adoption in the Malaysian construction industry?

A: *"Potential improvements include government incentives/tax relief for BIM adoption, integrating BIM into university engineering curricula, and authorities mandating BIM for certain projects."*

Theme 3: Future Plans and Trends

Q1: Are there any plans to further expand BIM adoption within your company right now?

A: *"The company plans to expand BIM usage by hiring more BIM-experienced staff and providing training for existing staff."*

Q2: In your opinion, what are the key trends that will shape the future of BIM adoption in Malaysia? over the next five to ten years?

A: *"Future trends may include integrating BIM with AI and further improving BIM software to better reflect actual design intent."*

Q3: For the future, do you think that BIM will become a norm of the organization in the future? And why do you say so?

A: *"BIM is expected to become the norm in the Malaysian construction industry, with 80-85% of projects using it in the next 5-10 years, once the cost and awareness challenges are addressed."*

Appendix C: Questionnaire

EXPLORE BUILDING INFORMATION MODELLING (BIM) APPLICATION AND PERFORMANCE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Dear Sir/Madam,

Good day! ✨ You are invited to participate in a final year project conducted by Koh Yen Zi, a final year undergraduate student, currently pursuing Bachelor of Science (Honors) Quantity Surveying in Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus.

The objectives of this study are
(i) To examine the current implementation stage of BIM in the Malaysian construction industry
(ii) To investigate barriers hindering the process of BIM implementation in the Malaysian construction industry
(iii) To identify solutions to increase the adoption of BIM in the Malaysian construction industry

To participate in this study, you **should be a current or an existing users of Building Information Modelling (BIM)** in the Malaysian Construction Industry.
If you have used BIM software in previous/ current projects such as Naviswork, CostX, Autodesk Revit, Archicad, SketchUp and other relevant BIM software then you are considered as a current or an existing BIM users.

This questionnaire comprised of 5 sections and it will take approximately 10 minutes to complete.
Your information and data will be kept strictly private and confidential. All associated data collected will be used purely for academic purpose.

Should you have any enquires about this research study, kindly contact me, Koh Yen Zi at 018-2366520 or clara1206@1utar.my.

Thank you for your participation and time.
Yours faithfully,
Koh Yen Zi
Bachelor of Science (Honours) Quantity Surveying
Universiti Tunku Abdul Rahman

* Indicates required question

1. Consent Form *

Mark only one oval.

- ⬭ I have been notified by you and that I hereby understand, consent and agreed per UTAR above notice.
- ⬭ I disagree, I do not consent to this study.

Section A: Respondents' Demographic Information

2. 1. How many years have you been working in the construction industry? *

Mark only one oval.

- ⬭ 0-2 years
- ⬭ 3-5 years
- ⬭ 6-10 years
- ⬭ 11-20 years
- ⬭ More than 20 years

3. 2. Which of the following best describes your role in the construction industry? *

Mark only one oval.

- ⬭ Architect
- ⬭ Engineer
- ⬭ Quantity Surveyor
- ⬭ Contractor
- ⬭ Developer
- ⬭ Other: ________________

4. 3. Which of the following best describes the size of your organization (number of employees)? *

Mark only one oval.

- ⬭ Small (3-19 people)
- ⬭ Small to medium (20-50 people)
- ⬭ Medium to large (51-200 people)
- ⬭ Large (more than 200 people)

5. 4. What is the CIDB Grade of your company? *

Mark only one oval.

- ⬭ G1
- ⬭ G2
- ⬭ G3
- ⬭ G4
- ⬭ G5
- ⬭ G6
- ⬭ G7
- ⬭ Not applicable

6. 5. Are you a current or existing BIM user? *

If you have used BIM software in previous/ current projects such as Naviswork, CostX, Autodesk Revit, Archicad, SketchUp and other relevant BIM software then you are considered as a current or an existing BIM users.

Mark only one oval.

- ⬭ Yes
- ⬭ No *Skip to question 16*

Section B: Examine the current implementation stage of BIM

Please indicate the level of agreement on the current implementation stage of BIM.

7. Please rate your **familiarity** for software below. *

Mark only one oval per row.

	Not Familiar	Slightly Familiar	Moderately Familiar	Very Familiar	Extremely Familiar
Autodesk Revit					
Archicad					
Autodesk Naviswork					
SketchUp					
Bim 360					
Vectorworks					
Allplan					
HoloBIM					
CostX					
Trimble Tekla					

Trimble Tekla / Cubicost TAS					
Cubicost TAS / Cubicost TRB					
Cubicost TRB / Cubicost TBQ					
Cubicost TBQ					

8. To what extent you **apply** the following software in your projects? *

Mark only one oval per row.

	Never	Rarely	Sometimes	Often	Always
Autodesk Revit	⬭	⬭	⬭	⬭	⬭
Archicad	⬭	⬭	⬭	⬭	⬭
Autodesk Naviswork	⬭	⬭	⬭	⬭	⬭
SketchUp	⬭	⬭	⬭	⬭	⬭
Bim 360	⬭	⬭	⬭	⬭	⬭
Vectorworks	⬭	⬭	⬭	⬭	⬭
Allplan	⬭	⬭	⬭	⬭	⬭
HoloBIM	⬭	⬭	⬭	⬭	⬭
CostX	⬭	⬭	⬭	⬭	⬭
Trimble Tekla	⬭	⬭	⬭	⬭	⬭
Cubicost TAS	⬭	⬭	⬭	⬭	⬭
Cubicost TRB	⬭	⬭	⬭	⬭	⬭
Cubicost TBQ	⬭	⬭	⬭	⬭	⬭

9. Are there other BIM software programs you have used on past or current projects, besides the ones listed? If yes, please state. *

Mark only one oval.

- No
- Other: ____________

10. BIM used in organizations for *

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Coordination/Clash detection					
Visualization					
Project Planning					
Estimating					
Scheduling					
Take-Offs					
Virtual Mock-ups					
Presentation					
Prefabrication					
Facility Management					

11. Source of information about BIM *

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
CIDB Malaysia	⬭	⬭	⬭	⬭	⬭
BIM consultant	⬭	⬭	⬭	⬭	⬭
Professional bodies/institute	⬭	⬭	⬭	⬭	⬭
Social media	⬭	⬭	⬭	⬭	⬭
University	⬭	⬭	⬭	⬭	⬭
Publication	⬭	⬭	⬭	⬭	⬭
Online Journal	⬭	⬭	⬭	⬭	⬭

Section C: Barriers of BIM implementation

Please indicate the level of agreement on the barriers of BIM implementation.

12. Barriers of BIM implementation *

*Interoperability refers to the ability of different software applications to exchange and understand information seamlessly.

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Lack of interoperability*	◯	◯	◯	◯	◯
Complexity of BIM model	◯	◯	◯	◯	◯
High initial & training cost	◯	◯	◯	◯	◯
ROI (Return on investment) not clearly defined	◯	◯	◯	◯	◯
Lack of government involvement	◯	◯	◯	◯	◯
Lack of industrial standards	◯	◯	◯	◯	◯
Intellectual property rights & ownership of BIM	◯	◯	◯	◯	◯
Resistance to change	◯	◯	◯	◯	◯
Lack of BIM education & training	◯	◯	◯	◯	◯
Lack of BIM benefits awareness	◯	◯	◯	◯	◯
Lack of BIM skilled workers	◯	◯	◯	◯	◯

Lack of time to implement	◯	◯	◯	◯	◯

13. For other barriers (if any), please state

____

____

____

____

____

Section D: Solution to increase the adoption of BIM

Please indicate the level of agreement on the solution to increase BIM adoption.

14. Solution to increase the adoption of BIM *

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Top management support	◯	◯	◯	◯	◯
Project preparation	◯	◯	◯	◯	◯
Team Capability	◯	◯	◯	◯	◯
Cooperation by training	◯	◯	◯	◯	◯
Industry awareness	◯	◯	◯	◯	◯
Technology access	◯	◯	◯	◯	◯
Individual motivation	◯	◯	◯	◯	◯
Education	◯	◯	◯	◯	◯
Government initiatives	◯	◯	◯	◯	◯
Standardization efforts	◯	◯	◯	◯	◯

15. For other solutions (if any), please state

____

____

____

____

____

Section E : Awareness of BIM in construction industry

16. Have you ever heard about Building Information Modeling (BIM)? *

Mark only one oval.

- Yes
- No

17. If BIM training open for all construction companies to join, how enthusiastic are you participating? *

Mark only one oval.

- Not at all: No interest in participating in the open BIM program.
- Rarely: Unlikely to participate actively, may require significant incentives.
- Moderate: Interested in participating, but with some reservations or a wait-and-see approach.
- Very: Highly motivated to participate and contribute to the program.
- Extremely: Eager to participate actively and be a leader in the open BIM program.

18. BIM provides benefits for project implementation, how much extent do you agree? *

Mark only one oval.

- Strongly disagree: BIM provides no real benefits for project implementation, and may even hinder the process.
- Disagree: BIM offers limited advantages for project implementation, and its value is questionable.
- Neutral: BIM may have some benefits for project implementation, but its effectiveness depends on specific circumstances.
- Agree: BIM offers clear advantages for project implementation, with positive impacts on various aspects.
- Strongly agree: BIM provides substantial benefits for project implementation, leading to improved efficiency, reduced costs, and better communication.

19. Willingness to change for BIM adoption *

Mark only one oval.

- Highly Resistant: Unwilling to change current practices and strongly opposed to adopting BIM.
- Somewhat Resistant: Hesitant to change existing workflows and may require persuasion for BIM adoption.
- Neutral: Uncertain about the need for change or BIM adoption, requires clear explanation of benefits.
- Willing: Open to change and supportive of BIM adoption efforts within the organization.
- Highly Willing: Eager to embrace change and actively participate in adopting BIM practices.

20. Is your organization aware and adopting BIM? *

Mark only one oval.

- Strongly Disagree: Organization is completely unaware of BIM.
- Disagree: Organization has limited knowledge of BIM.
- Neutral: Organization is somewhat aware of BIM but hasn't started any implementation.
- Agree: Organization is aware of BIM and has begun adopting it in some projects or for specific tasks
- Strongly Agree: Organization is actively aware of BIM and fully implementing it in projects.

The End

Thank you very much for spending your precious time in completing this survey. Your response is truly important for this study. Have a nice day ahead ~

This content is neither created nor endorsed by Google.

Google Forms