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Unveiling BIM Value from Subcontractors' Perspectives in The Malaysian Construction Industry

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Abstract

Building Information Modelling (BIM) has evolved as a strategic digital tool for enhancing collaboration and productivity in construction projects. While its adoption is steadily gaining momentum among main contractors, uptake among subcontractors, particularly small to medium-sized enterprises (SME), remains restricted due to contextual, organizational and technological constraints. This study assesses the subcontractors' perceptions of BIM's value and implementation challenges in Selangor, Malaysia. A structured quantitative survey was administered across G3 to G7 classified subcontractors as issued by the Construction Industry Development Board (CIDB) Malaysia, resulting in a response rate of 36.59. The findings reveal a relatively high level of awareness of BIM's benefits, particularly in enhancing 3D project visualization (Mean = 4.53) and facilitating the integration of design and construction processes (Mean = 4.30). Nevertheless, critical barriers persist, led by the 'Lack of clear direction for BIM implementation' (Mean = 4.13), 'Reluctance to initiate new operational workflows' (Mean = 4.10) and 'Inadequate team competency' (Mean =4.07). Overall, the results suggest that in order to overcome arising BIM challenges, comprehensive policy reform, targeted capacity-building training and stronger top-down mandates from project stakeholders and regulatory bodies are needed. These insights contribute to the valuable formulation of strategic interventions which capable of fostering inclusive digital transformation within the Malaysian construction sector.

1. Introduction

The construction industry significantly contributes to the country's socio-economic development. Prior to the introduction of the Fourth Industrial Revolution (IR 4.0), the construction process was a complex and multifaceted sector involving large labour forces. However, the advent of IR 4.0 has allowed the construction industry to progress by leaps and bounds, bringing it into an intelligent construction era [1]. In fact, IR 4.0 introduces value in transforming the construction sector business strategy. It has also revolutionized the industry by introducing digital technologies, sensor systems, intelligent equipment and smart materials, with BIM as the central repository for digital construction project data [2].

BIM was incorporated in the planning, execution and management of construction projects to enhance productivity, fostering collaboration and communication among stakeholders across project lifecycles [3]. The

Malaysian government sees this as a game-changing advancement in the construction industry and has consistently supported the BIM initiative since its inception in 2007 [4]. Consequently, BIM represents a vital instrument in its efforts under the CITP framework, which focuses on productivity enhancement in its master plan. According to CIDB Malaysia [5], BIM resembles as a sophisticated ICT innovation which includes modelling technology and a respective set of processes to develop, communicate, analyse and apply digital information models across the project lifecycle. To harness the full potential and benefits of Construction 4.0, a five-year strategy plan spanning from 2021 to 2025 has been proposed [6].

In recent years, prominent stakeholders such as property developers and main contractors have increasingly recognized the benefits offered by BIM applications, resulting in a notable growth of its adoption [7][8]. In spite of this rising trend, it has not been mirrored among SMEs, notably subcontractors, who remain largely hesitant to embrace BIM technologies. In most cases, BIM implementation within SME's remains minimal or non-existent, indicating limited engagement beyond basic awareness or pilot use. This can be attributed to limited levels of BIM usage and digitalisation, which continue to exhibit relatively low productivity and limit the recognition of SMEs as efficient contributors within the construction sector [9].

As a matter of fact, previous studies on BIM awareness and challenges conducted in Malaysia are mainly covered in a general context. Thereby, this study aims to discover the perspectives of subcontractors in Selangor, with particular attention to their awareness of BIM value and barriers they encounter. As key intermediaries in the construction supply chain, subcontractors often serve as vital communication links between multiple project stakeholders. By understanding their viewpoint, it will gradually help in identifying practical challenges and subsequently unveiling potential strategies to facilitate wider BIM adoption within construction projects.

2. Literature Review

In reference to Othman et al. [4], only 13% of participants from both the public and private sectors reported implementing BIM within their organizations, indicating that the industry remains in the infancy stages of adoption. Supporting this observation, a study by Kong et al. [8] found that BIM adoption rates were as low as 5.2%, with only 52.6% of respondents aware of BIM's existence, which underscores the substantial gap between awareness and practical implementation among SMEs.

This fragmented nature of Malaysian BIM implementation is largely attributed to the combination of technical adoption, behavioural, managerial and implementation-related challenges. Waqar, Qureshi and Alaloul [10] identified the BIM barrier-based framework as listed in the following order: 'Managerial' category as the most critical, followed by 'Technical Adoption', 'Implementation' processes and 'Behavioural' resistance. Managerial-related issues such as the impact of COVID-19, changes in efficiency due to BIM adoption and the difficulties in managing a diverse workforce explain 28.015% of the variance. Post-pandemic era affects the SME's lacked in resources to invest in technologies, which leads to a major obstacle for BIM adoption[11][12]. In addition, Malaysia's construction workforce is highly varied by having many workers from countries like Bangladesh and India, which poses communication and coordination challenges for BIM adoption. Next, the second major group of challenges in BIM implementation involves technical issues which account for 6.041% of the total variance. These include the lack of a clear and supportive implementation process, impractical theoretical research findings, absence of training centers, poor BIM integration with project activities, lack of legal regulations, high BIM costs, weak quality control processes and low awareness of BIM benefits. The scarcity of training opportunities hinders the ability of SME's to implement BIM [13]. Not just that, clients with limited budgets may not require BIM usage and poor integration techniques increase costs, leading to further challenges within SMEs that might not be technically ready for BIM adoption.

Furthermore, the third group of implementation barriers represented 5.847% of the total variance. It highlights a lack of financial support and the risk of project delays as the top issues. Eventually, the fear of delays adds uncertainty to the whole process and might cause workers to encounter misunderstandings[14]. Besides, financial constraints which are generally connected to limited government support, make it harder for SMEs to invest in BIM. Lastly, from the behavioural group, which includes a lack of demand from clients, strong resistance to BIM adoption in the workplace, reluctance to change existing practices, limited involvement from team members besides the team leader and the absence of a simple or standard guideline for BIM usage. Eventually, many workers are hesitant to change their usual routines, which therefore increases behavioural resistance. Also, the lack of knowledge and skills in applying BIM hardens the adoption process, especially when no clear method is provided[10][15]. These interconnected factors collectively hinder the widespread and efficient integration of BIM into construction practices, particularly within resource-constrained organizations.

Therefore, in order to encounter various challenges that arise, Ahankoob et al. [16] emphasized that the widespread adoption of BIM is strongly influenced by the industry's perception of its tangible benefits, where potential users should be encouraged through empirical evidence. Supporting this view, the ANOVA survey findings from the study indicate that the level of expertise and experiences of industry practitioners towards BIM utilization serves as a critical factor in recognizing BIM benefits. Collectively, it indicates that increased exposure and experience with BIM fosters greater understanding of its business value, particularly among subcontractors within the SME sectors. Multiple BIM benefits can be obtained through their functions as information repositories of the properties. For instance, BIM serves consistent project information throughout the entire lifecycle – from design to construction which promotes transparent information flow across the supply chain. In addition, not just restricted to reliable and real-time exchange of information, current BIM evolution has also integrated advanced properties with the time dimension, namely 4D BIM for clearer understanding of the project planning sequence through visualization and 5D BIM which provides model-based cost estimation to improve reliable and accurate cost estimations [16].

Thus, findings from Othman et al. [4] recommend organizations to take a proactive strategy in adopting BIM critically and encourage professionals to enhance their expertise in BIM adoption. This initiative can be done through participation in training programs for theoretical understanding as well as hands-on practice with the BIM technology itself for practical skills and knowledge development.

3. Methodology

The methodology flow chart for this research is depicted in Figure 1, illustrating the entire process of the research methodology.

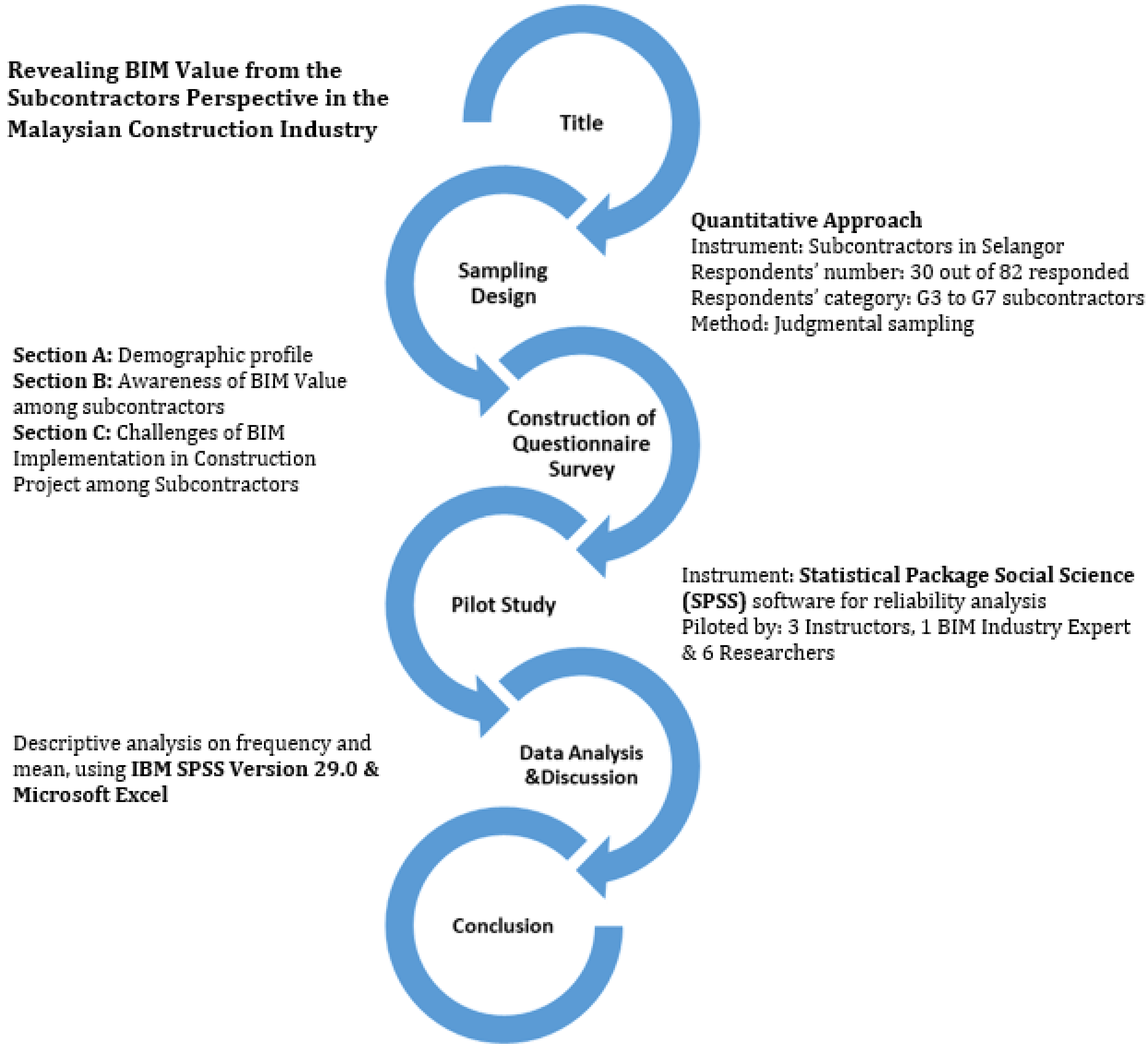


Fig. 1 *Methodology flow*

3.1 Quantitative Analysis

In general, quantitative analysis is suitable to be applied when adequate and representative data are readily accessible [10]. This approach is particularly effective in minimizing bias, demonstrating validity and reliability, testing hypotheses, assessing causal relationships, forecasting phenomena and quantitatively measuring variables.

Therefore, this study employed a quantitative approach for data collection, utilizing judgmental sampling also known as purposive sampling. Bhardwaj [11] defines judgmental sampling as a discretion method in selecting individuals with relevant expertise on the subject matter to provide rich and relevant data. This approach specifically targets a defined subset of the population, involving the selection of potential subcontractors from firms based in the Selangor district, which is consistently recognized as the most construction-driven region in Malaysia with higher BIM adoption rate. These firms primarily operate in civil engineering, building construction, Mechanical, Electrical and Plumbing (MEP) services and precast operations sectors deemed relevant to the research objectives. For instance, subcontractors registered under the CIDB, ranging from G3 to G7 classifications, were purposively selected as they are more likely to be engaged in advanced construction practices such as BIM.

In the Malaysian construction industry context, G3 to G7 subcontractors are distinguished by financial capacity and project value limits. Notably, G3 subcontractors are limited to projects of up to RM1 million, whereas G7 subcontractors have no limit on the size of projects they can undertake. On top of that, the questionnaire was structured into 3 main sections: Section A – Demographic Information, Section B and Section C – A 5-point Likert scale (1-low to 5-high) to evaluate BIM awareness and challenges of its implementation in construction projects.

3.2 Pilot Study

The pilot study for this research was evaluated through validity and reliability analysis to eliminate data inaccuracies. For the validity analysis, the questionnaire design was reviewed by an academician staff and one industry expert whose work relates to BIM. Meanwhile, the reliability analysis involved input from three instructors, a BIM expert and six researchers who conducted a series of structured assessments to identify and remove unreliable or misaligned questions with the research objectives. Reliability tests for each variable were conducted using Cronbach's alpha in SPSS, with values ranging from 0 to 1 and a minimum value of 0.6 is the threshold for acceptable reliability in exploratory research [17]. Table 1 provides an overview of the Cronbach's alpha results from the reliability analysis.

Table 1 Reliability test results

Scale	Number of factors under consideration	Cronbach's alpha
Section B: Awareness of BIM value among subcontractors	19	0.892
Section C: Challenges of BIM implementation among subcontractors	23	0.731

Sections B and C of the pilot study questionnaire have a valid reliability analysis. Based on the Cronbach's Alpha Score, Section B scored 0.892 at the good level, while Section C scored 0.731 at the acceptable level, indicating a satisfactory questionnaire for the Likert scale survey.

3.3 Data Collection and Analysis

The survey employed an online questionnaire through Google Forms via Email, WhatsApp and Telegram distributions due to time efficiency, cost effectiveness, flexibility, accessibility and ability to generate high-quality responses. The questionnaire was meticulously designed based on insights from literature reviews. Data collection was conducted over three weeks, with responses secured in a Google-supported database. The CIDB website served as the primary source to identify BIM potential respondents.

Overall, of the 82 questionnaires distributed to subcontractors' firms in the Selangor district, 30 were completed, earning a response rate of 36.59%. The low response rate confirmed the industry at a low level of BIM implementation during the construction phase, as highlighted by Othman et al. [4] compared to modelling parts of the design phase. However, all responses were valid as respondents were ensured to have prior experience with BIM applications. According to survey findings in construction engineering and technology management, it suggests that above 20% response rate is acceptable when utilizing judgmental sampling [18].

For data analysis, IBM's SPSS Version 29.0 software was utilised, particularly concerning demographic information. This software represents the latest data analysis programme, designed to meet evolving analytical requirements and accommodate advanced analytical techniques [12]. In addition to SPSS, Microsoft Excel was used to generate charts for descriptive analysis. On top of that, the rest of the questionnaire was calculated using mean and standard deviation (SD) as shown in Eq. 1 and Eq. 2, respectively. As stated by South et al. [19], when analyzing Likert scale data, the mean is a more accurate measure of central tendency than the median and the best fit statistical tool in analyzing Likert scale data is through SD, as it reflects the degree of data dispersion around the mean [20].

$$Mean\ (x) = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (1)$$

Where:
x = mean score
x_i = individual Likert scale response
N = total number of responses

$$Standard\ Deviation\ (s) = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - x)^2 \quad (2)$$

Where:
S = sample standard deviation
N = total number of responses
x_i = individual Likert scale response
x = mean score

4. Results and Discussion

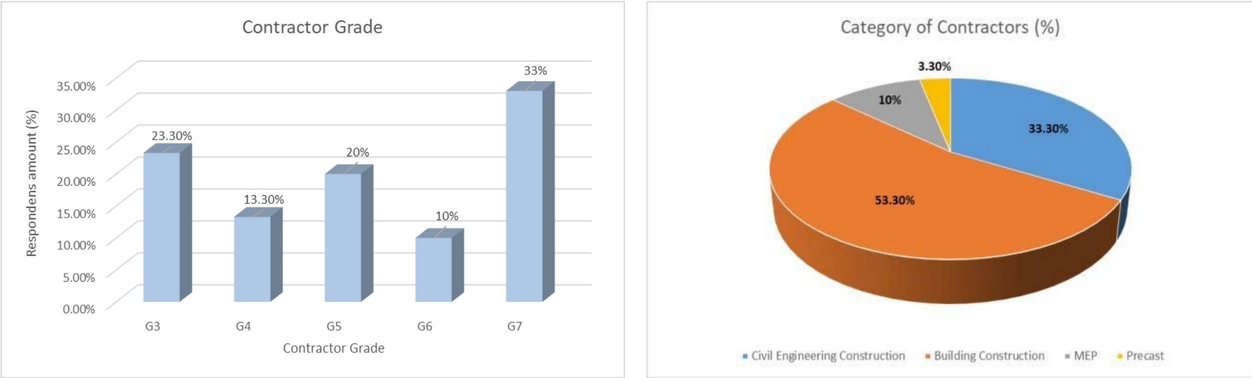
4.1 Demographic Information

The demographic section encompasses 4 main factors related to respondents' backgrounds such as contractor grade, category of contractors, position in the company and years of experience in handling BIM. Figure 2(a) depicts the distribution of respondents across various contractor grades, with the majority scores of 33.3% from G7, followed by G3 (23.3%), G5 (20%), G4 (13.3%) and G6 (10%). These findings are reliable since G7 represents the highest contractor classification in Malaysia with substantial financial and technical capability in completing large-scale projects. Eventually, their dominance in the response indicates a higher likelihood of exposure to complex projects where BIM adoption is needed. Yet, the significant involvement of lower-grade contractors ranging from G3 to G5 suggests that the BIM adoption is moving beyond top-tier organization and into SME sectors.

Concurrently, Figure 2(b) confirms this finding, with 53.3% of respondents engaged in the building construction and civil engineering construction (33.3%) representing the vast majority. These two categories are often depicted as the forefront of BIM adoption due to their focus on complex design-intensive and critical coordination, where BIM tools are capable of enhancing efficiency through error reduction. In contrast, MEP (10%) and precast (3.30%) contractors have low participation, which might reflect slower BIM adoption among specialist subcontracting industries. This gap highlights the need to tailor BIM adoption outreach and training programs to meet the specific needs of minority industries that lag in digital BIM adoption.

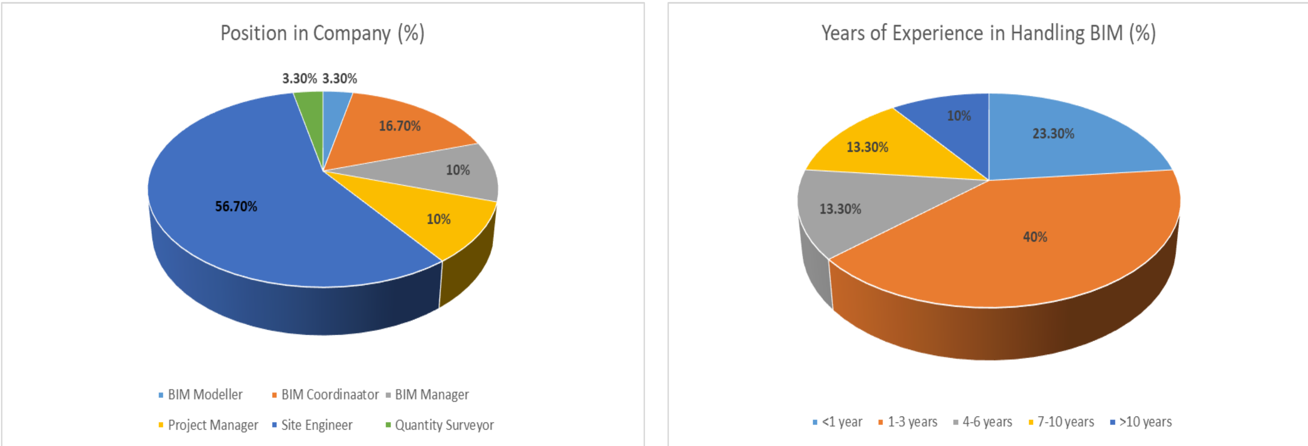
Next, Figure 3(a) outlines respondents' roles in their company. A large majority (56.7%) were identified as BIM modellers, reflecting technical involvement with BIM procedures. Following that are BIM coordinators with 16.70%, project managers and BIM managers with 10%, as well as site engineers and quantity surveyors with 3.30%, respectively. The high participation of BIM modellers reflects the increasing reliance on BIM tools at the operational level, enabling real-time problem-solving and improved communication between design and construction teams. However, for BIM to be utilized to its full potential, leadership roles are crucial in actively participating in the digital transformation rather than simply delegating it to technical staff.

Lastly, Figure 3(b) shows that 40% of the respondents have experience handling BIM between 1-3 years, followed by 23.3% with less than 1 year, similar record of 13.3% for both 4-6 years and 7-10 years and only 5% have experience over 10 years. This reflects its recent adoption and growing prominence in Malaysia's construction industry, with the majority of respondents having limited experience. In some way, this response is consistent with prior research, which has highlighted the lack of competent and skilled staff as a major challenge towards BIM adoption in developing construction markets like Selangor, Malaysia.



(a) **(b)**

Fig. 2 *(a) Contractor grade; (b) Category of contractors*



(a) **(b)**

Fig. 3 *(a) Position in the company; (b) Years of experience in handling BIM*

4.2 Awareness of BIM Value among Subcontractors

This section comprises 19 elements distributed across three categories, designed in a Likert-scale format to assess subcontractors' awareness of BIM's value. The three categories evaluated are: 'Coordination among the Construction Stakeholders', 'Enhancement of Project Process and Technical Coherence and 'Financial Impact of BIM Adoption' as presented in Table 3.

Table 3 *Rank order for awareness of BIM value among subcontractors*

Category/ Elements	Mean	Standard Deviation (SD)	Interpretation	Internal Rank	Overall Rank
i) Enhancement of Project Process and Technical Coherence					
BIM helps in better project visualization and the generation of 3D views.	4.53	0.571	High	1	
BIM helps in the better integration of design and construction.	4.30	0.651	High	2	
BIM helps in early clash detection between building elements and components.	4.17	0.874	High	3	**1**
BIM enhance the installation methods in construction projects.	4.13	0.819	High	4	
BIM increases information accuracy.	4.10	0.607	High	5	
BIM gives value to the sequence arrangement of construction tasks.	4.07	0.691	High	6	
BIM helps in health and safety control throughout the construction process.	3.77	0.679	High	7	
BIM helps in speeding up the project schedules.	3.70	0.837	High	8	
Average Mean Score	4.10	0.478	High		
ii) Coordination among the construction stakeholders					
BIM enhances the involvement of key stakeholders at an early stage.	4.10	0.995	High	1	
BIM provides better collaboration among different team players.	4.07	0.980	High	2	**2**
BIM helps in the productivity and efficiency of the project.	4.03	0.850	High	3	
BIM can easily be managed by multiple disciplines.	3.60	1.003	Moderate	4	
Average Mean Score	3.95	0.818	High		
iii) Financial impact of BIM adoption					
BIM increases savings in the construction stage.	4.13	0.776	High	1	
BIM helps in material savings.	4.00	0.695	High	2	
BIM implementations save more overall cost than not implementing it.	4.00	0.743	High	3	
BIM increases savings in the design stage.	3.97	0.765	High	4	**3**
BIM increases savings in the building operation stage.	3.63	0.615	Moderate	5	
BIM helps in labour cost savings.	3.63	0.809	Moderate	6	
BIM increase overall project ROI by at least 20%.	3.60	0.621	Moderate	7	
Average Mean Score	3.85	0.474	High		
Total Average Mean Score	**3.97**	**0.483**	**High**		

The first category of 'Enhancement of Project Process and Technical Conference' obtained the highest average mean score (Mean =4.10, SD = 0.478), indicating a strong awareness among subcontractors of BIM's technical benefits. In particular, the element 'BIM helps in better project visualization and the generation of 3D views' was ranked first overall (Mean= 4.53), promoting that visual clarity and design comprehension are identified as the most highly valued features of BIM by subcontractors. This aligns with a previous study of Sinoh et al. [21] that emphasize visualization as one of the core and most effective advantages in BIM uptake. Likewise, the high-ranking elements such as 'BIM helps in better integration of design and construction' (Mean = 4.30) and 'BIM helps in early clash detection between building elements and components' (Mean = 4.17), highlight subcontractors' recognition of BIM's role in reduction of rework and minimization in coordination errors [22], which highly related to major challenges in construction practices. These findings demonstrate an increasing technical appreciation for BIM, particularly in complex contexts where subcontractors are required to coordinate across various interfaces. Additionally, while all elements in this category were evaluated as 'High', health and safety control (Mean = 3.77) and schedule acceleration (Mean = 3.70) received the lowest rankings. This could probably imply a lower influence on BIM operational site management and productivity outcomes, indicating areas where additional education or proven profit is required.

The second category of 'Coordination among Construction Stakeholders' carries an average high mean score of 3.95. The top-rated element here includes 'Better collaboration among different team players' (Mean= 4.07) in second rank, and next 'Increased productivity and efficiency' (Mean = 4.03). These findings are consistent with previous literature reviews that describe BIM as a facilitator of integrated project delivery and multidisciplinary [7]. Yet, the lower score for 'BIM can easily be managed by multiple disciplines' (Mean= 3.60) suggests a perception gap regarding the ease and friendliness of BIM integration across diverse disciplines. This might be likely related to current limitations in interoperability, standards alignment and workforce competence. On top of that, this could also relate to challenges among subcontractors when operating in heterogeneous digital environments, particularly when upstream players vary in BIM maturity levels.

The third category of 'Financial impact of BIM adoption' recorded the lowest overall mean score (Mean = 3.85, SD =0.474) however, it still falls within the 'High' interpretation range. The highest ranking involves 'BIM increases savings in the construction stage' (Mean = 4.13), suggesting that subcontractors primarily distinguished BIM as a tool to enhance cost efficiency during the construction phase, which aligns closely with their direct scope [17]. Nevertheless, the financial benefits of BIM in other project phases, namely the building operation stage and labour cost savings with a similar mean of 3.63, respectively, were identified only at the 'Moderate' level. The item 'BIM increase overall project ROI by at least 20%' is classified with the lowest score in this category (Mean =3.60). These findings suggest that subcontractors may have a limited awareness towards BIM's long-term financial advantages [15]. It is noteworthy that the BIM financial benefits are frequently indirect, deferred or realized primarily at the project level rather than within the subcontractor's scope. As a result, unless cost-saving outcomes are clearly demonstrated through contractual arrangements, subcontractors may remain skeptical of BIM's economic value. This finding is parallel with a study from Olanrewaju et al. [22] who discovered economic barriers as one of the most enduring barriers towards BIM adoption among SMEs.

Table 4 provides a summary of vital insights into the precise elements of BIM that Malaysian subcontractors, particularly based in Selangor, value the most. The analysis places a major emphasis on the technical and procedural improvements, however, less noticeable recognition towards financial consequences.

Table 4 *Top 5 critical BIM values among subcontractors*

Elements	Category	Mean	Rank
BIM helps in better project visualization and the generation of 3D views.	Enhancement of Project Process and Technical Coherence	4.53	1
BIM helps in the better integration of design and construction.	Enhancement of Project Process and Technical Coherence	4.30	2
BIM helps in early clash detection between building elements and components.	Enhancement of Project Process and Technical Coherence	4.17	3
BIM increases savings in the construction stage.	Financial impact of BIM adoption	4.13	4
BIM enhance the installation methods in construction projects.	Enhancement of Project Process and Technical Coherence	4.13	5

All in all, the clustering of top-ranked elements under the 'Enhancement of Project Process and Technical Coherence' category indicates that they primarily value BIM for its operational and technical utility. The findings propose a growing realization of BIM's role in project integration, accuracy and planning efficiency, yet also emphasize a relatively narrow perception of its financial and strategic potential. To foster more holistic BIM adoption, stakeholders such as policymakers, main contractors and technology suppliers must work together in order to expand subcontractors' understanding of BIM's value across the full project life cycle, including ROI, sustainability and facility management. Additionally, customized training modules and project demonstrations should highlight how BIM could contribute to cost certainty, project predictability and business competitiveness even among subcontractor firms.

4.3 Challenges of BIM Implementation in Construction Projects among Subcontractors

BIM adoption has been widely recognized as a transformative technology process in the construction industry. Despite, its implementation presents multiple challenges that hinder its full potential. Table 5 identifies and categorized these challenges in accordance with ranking via 4 categories of 'Process', 'People', 'Policy' and 'Cost'.

Table 5 *Rank order for challenges of BIM implementation among subcontractors*

Challenges	Mean	Standard Deviation	Interpretation	Internal Rank	Overall Rank
i) Process					
Lack of direction of BIM in the industry	4.13	0.860	High	1	
Inadequate familiarity with the use of BIM	4.03	0.809	High	2	
Lack of time for experimentation and implementation in fast-paced projects	3.97	0.718	High	3	**1**
Difficulty in process change management	3.97	0.850	High	4	
Lack of references to assist in BIM implementation	3.90	0.845	High	5	
Lack of time to implement BIM	3.57	0.817	Moderate	6	
Average Mean Score	3.93	0.550	High		
ii) People					
Reluctance to initiate new workflows for the implementation of BIM	4.10	0.759	High	1	
Lack of competency among team members in using BIM	4.07	0.828	High	2	
Lack of knowledge in BIM	3.93	0.691	High	3	**2**
Insufficient availability of BIM training	3.80	1.031	High	4	
Lack of awareness of BIM benefits	3.73	0.980	High	5	
Average Mean Score	3.93	0.623	High		
iii) Policy					
BIM usage is not required by main contractors or clients	4.00	1.017	High	1	
BIM usage is not required by main contractors or clients	3.83	0.834	High	2	**3**
Data ownership	3.60	0.814	Moderate	3	
Average Mean Score	3.81	0.682	High		
iv) Cost					
High-cost investment in high-technology software licensing	3.93	0.785	High	1	
High cost of software	3.87	0.900	High	2	
High cost of hardware	3.57	0.971	Moderate	3	
High training cost	3.50	0.820	Moderate	4	**4**
Premium staff salary of BIM expert	3.43	0.774	Moderate	5	
High-cost BIM consultancy fees	3.40	0.770	Moderate	6	
Average Mean Score	3.62	0.605	Moderate		
v) Technology					
BIM software is complicated to use	3.33	0.922	Moderate	1	
Existing hardware is incapable of running basic BIM software	3.20	1.095	Moderate	2	**5**
Low cybersecurity	2.90	1.094	Moderate	3	
Average Mean Score	3.14	0.801	Moderate		
Total Average Mean Score	3.69	0.339		High	

First and foremost, through 'Process' category analysis, it records the highest average mean score of 3.93 overall, representing that process-related challenges are the most critical bottlenecks for BIM adoption among subcontractors in Selangor. The top challenge was related to 'Lack of BIM direction in the industry' (Mean = 4.13, SD = 0.860), which highlights the industry's absence of a clear and industry-based roadmap, resulting in fragmented approaches to BIM need for clearer guidance on guidelines and frameworks for BIM adoption [2]. This can be resolved by establishing macro-level BIM policies and standards to drive micro-level execution. The second challenge is 'Inadequate familiarity with the use of BIM', with scores of Mean = 4.03. This suggests a gap in digital literacy and familiarity between BIM tools, reflecting the findings from Sacks et al. [7] to emphasize education learning as well as continuous training for successful BIM uptake. Meanwhile, the third challenge is the 'Difficulty in process change management' (Mean = 3.97). Subcontractors often encounter resistance to transforming conventional workflows to a BIM-oriented nature. The findings highlight the demand for a structured organizational transformation, leadership support and standardized guidelines to navigate better BIM implementation at the subcontractor level.

Moving on to the next category, involving 'People' with an average mean score of 3.93, is deemed central towards BIM's successful implementation. The results portray a high perception of difficulties with the most critical rank issue being behavioural. 'Reluctance to initiate new workflows' causes cultural resistance where behavioural intention is influenced by social norms. Not just that, the second highest challenge involving 'Lack of competency among team members' which reflects that BIM competency remains unevenly distributed among subcontractors, as this aligns with a study from Noor Akmal Adillah et al. [15], who pointed out that skill gaps undermine collaborative processes. Lastly, the 'Lack of awareness of BIM benefits' (Mean =3.73) element that challenges many subcontractors to fully understand and apply BIM's potential in enhancing project delivery. Thus, implementing a strategy centered on individuals by incorporating training, which encourages behavioural adaptation and motivation through incentives, is vital [22].

Subsequently, the policy-related challenges reflect systemic limitations arising from insufficient external mandates or client requirements to promote BIM adoption. The highest ranked policy barrier involves 'BIM usage is not required by main contractors or clients element (Mean = 4.00), showing that top-down enforcement is critical. By right, with the absence of demand from them, subcontractors will continue to lack motivation for BIM capabilities investment. In addition, ' Data ownership' challenge with a mean of 3.60 explains the uncertainty of its surrounding that hinders open information exchange as a major legal and contractual obstacle within BIM environments [15].

While cost-related issues carry a lower average mean score, somehow they are still interpreted as moderate concerns, considering the financial constraint imposed by smaller subcontractors. The 'High cost investment in software licensing' with a mean of 3.93, resulted as the most significant cost issue since BIM software entails high license fees, particularly burdensome for SME [11]. Following that, 'High cost of training' (Mean =3.87) challenge that is non-billable, discourages subcontractors from investing in workforce upskilling without external incentives. On top of that, the challenge of 'Premium staff salary of BIM experts' (Mean = 3.50) is causing subcontractors to experience difficulties in recruitment or retaining skilled experts. For this reason, the need for financial incentives, subsidies and shared resource platforms is essential to decentralize access to BIM knowledge.

Table 5 presents a summary of vital insights into the critical BIM challenges that Malaysian subcontractors, particularly based in Selangor, are confronted with the most. The analysis places a multifaceted emphasis on the 'Process', 'People' and 'Policy' categories.

Table 6 *Top 5 critical challenges in BIM implementation among subcontractors*

Challenges Elements	Category	Mean	Rank
Lack of direction of BIM in the industry	Process	4.13	1
Reluctance to initiate new workflows for the implementation of BIM	People	4.10	2
Lack of competency among team members in using BIM	People	4.07	3
Inadequate familiarity with the use of BIM	Process	4.03	4
BIM usage is not required by main contractors or clients	Policy	4.00	5

The findings from Table 6 conclude that successful BIM implementation among subcontractors demands a balanced approach across policy, process and people dimensions. Systemic leadership and direction must be developed via policy/process, technical and workflow familiarity should be raised (process/people) and internal resistance needs to be addressed through incentives and training (people) [22]. A multifaceted strategy that includes legal mandates, educational outreach and organizational change management must be executed to expedite BIM implementation across subcontracting practices.

5. Conclusion

In summary, the inherently risk-averse nature of the construction industry has created significant barriers to fully leveraging the BIM's potential. This study highlights the persistent gap between BIM awareness and its implementation among Selangor subcontractors construction industry. Although subcontractors demonstrate strong recognition of BIM's value, especially in project visualization and design-process integration, yet their ability to adopt BIM remains restricted by organizational, procedural and policy-level challenges. It also reaffirms that subcontractors, despite being essential players in the construction chain, facing a lack of systemic support and operational readiness to execute BIM in full practice. In order to facilitate a powerful and widespread BIM adoption, establishing national guidelines tailored to subcontractors, enforcing top-down (client-contractor) level mandates and promoting cost-effective training mechanisms are helpful initiatives to be applied.

Nevertheless, this study has a few limitations since only subcontractors' firms in the Selangor area were targeted, which could not represent the entire views of all subcontractors in Malaysia. Besides, the findings from the questionnaire only represent the level of awareness of BIM value among subcontractors and barriers to adopting BIM. Thus, future research should broaden its scope across multiple viewpoints of construction roles and geographies within local construction practitioners, such as architects, engineers or stakeholders for a more comprehensive understanding of BIM's business value, as different roles may perceive the benefits from varying perspectives. Apart from that, integrating qualitative research methodology, namely in-person interviews could reveal interesting insights into the BIM business value. Via these efforts, BIM implementation is possible to transition from isolated adoption towards widespread adoption transformation.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design:*** *Peniel Ang Soon Ern;* ***data collection analysis and interpretation of results:*** *Tan Hui Min, Nur Izzah Mohd Noh;* ***draft manuscript preparation:*** *Nur Izzah Mohd Noh. All authors reviewed the results and approved the final version of the manuscript.*

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List of Abbreviations

Building Information Modelling - BIM
Small medium-sized enterprises – SME
Construction Industry Development Board – CIDB
Fourth Industrial Revolution - IR 4.0
Statistical Package Social Science – SPSS
Mechanical, Electrical and Plumbing – MEP
Standard deviation - SD

List of Symbols

x - mean score
x_i — individual Likert scale response
N - total number of responses
S - sample standard deviation