Diyala Journal of Engineering Sciences

Journal homepage: https://djes.info/index.php/djes

ISSN: 1999-8716 (Print); 2616-6909 (Online)

BIM Implementation in Malaysian Quantity Surveying: A Conceptual Framework for Success Aligned with the Strategic Plan 2021-2025

Ng Hock Seng[1], Ng Chiew Teng[1*], Norhazilan Md Noor[1], Sarehati Umar[1], Ng Teck Wei[2], Koh Heng Boon[3] and Fiona Tan Ching Ling[2]

[1]Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia
[2]Faculty of Built Environment, Tunku Abdul Rahman University of Management and Technology, Setapak, 53300 Kuala Lumpur, Malaysia
[3]Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia

ARTICLE INFO

Article history:
Received October 6, 2024
Revised January 12, 2025
Accepted January 31, 2025
Available online March 1, 2025

Keywords:
BIM
Building Information Modelling
Conceptual framework
Malaysia
Quantity surveying practices

ABSTRACT

The Public Works Department (PWD) Strategic Plan 2021-2025 outlines ambitious targets for Building Information Modelling (BIM) adoption, aiming for 50% by 2021 and 80% by 2025. Reflecting this trend, the Malaysian construction industry is progressively integrating BIM, which offers quantity surveyors a more reliable method, particularly for developing cost estimates. However, BIM in Malaysian quantity surveying practices (QSP) has been slow, leading to limited overall use of BIM in their professional practices. Given the urgent need to meet national BIM adoption targets and improve construction project outcomes, there was a pressing need to explore BIM capabilities, challenges, and strategic solutions to bridge the adoption gap. Using a quantitative approach, questionnaires were distributed to quantity surveyors in Klang Valley, Malaysia, with 120 respondents participating. The findings showed high reliability based on Cronbach's alpha and identified that BIM capabilities in refining cost plans with evolving design detail receive the highest ranking. The most significant challenge in conventional QSP was the absence of standardised documentation formats. Furthermore, early comprehension of BIM by top management was found to be the most effective strategy for BIM implementation in quantity surveying. A comparative analysis with other developing countries further supported these findings. Based on the results, a conceptual framework was developed to guide BIM adoption in the Malaysian quantity surveying profession. Overall, the research successfully meets its objectives and provides valuable insights for stakeholders on the potential benefits and challenges associated with BIM implementation in the future.

1. Introduction

At the forefront of Building Information Modelling (BIM) is the creation and management of digital representations that cover both the physical and functional attributes of places, making use of various tools and technologies [1]. The use of specialised tools in architecture, engineering, construction and operations (AECO) has positioned BIM as a preferred choice within the construction sector. Charef et al. [2] pointed out that BIM's various dimensions cover scheduling in 4D, costing in 5D, sustainability in 6D and facility management in 7D.

BIM adoption is slower in developing countries compared to developed countries [3]. BIM adoption rates have shown a marked increase in countries such as Singapore [4], Nigeria [5], United Kingdom [6] and China [7]. However, according to the Construction Industry Development Board (CIDB)'s

* Corresponding author.
E-mail address: nghockseng0728@gmail.com
DOI: 10.24237/djes.2025.18103

Building Information Modelling 2021 Report, Malaysia recorded a 55% adoption rate in 2021 which remains stagnant compared to other developed countries. Public Works Department (PWD) aims to reach 80% BIM implementation by 2025. Both the CIDB and the PWD in Malaysia actively promote BIM implementation through guidelines, personal training and the execution of BIM in public projects [8].

In this research, quantity surveyors (QS) are the main focus of their important role in project cost and contract management. They leverage digital data to efficiently handle information which moves beyond traditional authoritative roles. Spellacy et al. [9] and Assaad et al. [10] noted that the importance of QS in ensuring successful project delivery is evident, but challenges arise within the uncertainties of the construction industry, leading to obstacles in quantity surveying practice (QSP). To navigate these challenges, Mara et al. [11] discussed the knowledge-driven quality of QS professional services becomes paramount. This is further augmented through continuous employee training in QS firms that contribute to the smooth delivery of professional services.

However, Ismail et al. [12] revealed that many QSs are aware of BIM and have a fair understanding of it, but they have not yet implemented it in their professional practice. Therefore, it implies that the adoption rate of BIM among Malaysian QSs is still low. The current level of understanding seems to be a barrier to effectively applying BIM in practice, especially when it comes to incorporating BIM mechanisms into project cost calculations. Besides, Olatunji et al. [13] noted that there is no evidence that BIM will reduce the importance of QS functions or make the roles of QS less attractive in the future. On the contrary, there would be a significant uptake of BIM in QSP, which could lead to more creative developments in the field. In Malaysia, some studies such as [14] and [15] have proposed frameworks for BIM implementation in QSP, but these frameworks are outdated and focused on barriers and benefits without systemic solutions. This creates a research gap, as there is a pressing need for a more comprehensive and updated approach that aligns with current industry demands and government priorities. Therefore, this research aims to develop a conceptual framework for BIM implementation in Malaysian QSP by integrating findings from each research objective. It serves as a practical guide for Malaysian policymakers.

To bridge this gap, there are three objectives need to be achieved: (1) investigate BIM capabilities in Malaysian QSP, (2) address the challenges in conventional Malaysian QSP, and (3) propose strategies to enhance BIM implementation in Malaysian QSP.

2. Literature review

2.1 Building information modelling capabilities in quantity surveying practices

Yang et al. [16] developed a BIM-based model to estimate construction costs tailored for the initial architectural phase of a construction project (C1). BIM allows estimators to extract precise measurements and quantities of materials directly from the models (C2) [17]. Alzraiee [18] claimed that BIM can create exact cost estimates for different design alternatives (C3). Le et al. [19] introduced a system that integrates BIM and databases to update cost plans automatically with changes in building parameters (C4). Addressing this issue, a BIM-based information management platform was developed to ensure the storage, sharing, data retrieval, accessibility and redundancy of information (C5) [20].

Elyano and Yuliastuti [21] found that clash detection and resolution using BIM can save 10% on material costs for steel panels and ducting pipes (C6). Moreover, QSs can take advantage of BIM to access current cost information for design changes and eliminate the need for manual re-measurement (C7) [22]. Farooq et al. [23] concluded that a BIM-based cost checking tool is more efficient than traditional methods (C8). Sherafat et al. [24] introduced an automated approach using API to calculate bills of quantities from BIM models and databases (C9). According to Moayeri et al. [25], BIM guarantees that changes in design are uniformly implemented in different perspectives such as plans, elevations and 3D models (C10). However, in the process of design, the BIM design process helps clients better understand and be satisfied with the final design (C11) [26].

2.2 Challenges in conventional quantity surveying practice

According to Zhan et al. [27], the use of manual measurements in traditional QSP approaches can lead to miscalculations in material and trade work estimations (P1). Jamal et al. [28] explained that traditional methods require detailed remeasurements, especially for large buildings (P2). BIM is effective in reducing under and over measurement errors that commonly occur in traditional quantity surveying, thereby lowering the chances of disputes and financial claims between clients and contractors (P3). Tahmasebinia and Song [29] highlighted that design errors cause project estimates to be imprecise, requiring QSs to spend additional time on re-estimation and rectification (P4). According to Zainon et al. [30], the absence of BIM makes it difficult to create accurate drawings, which can lead to misinterpretations and assumptions (P5). Farouk et al. [31] stated that without BIM, misalignments between different drawings, such as architectural, structural and M&E drawings commonly occur, which can slow down a project and increase costs (P6). In their study, Azizi et al. [32] brought attention to issues within QSP, one being the absence of a standardised documentation format in QS consultancy firms (P7).

2.3 Strategies for Building Information Modelling Implementation in Quantity Surveying Practices (QSP)

Villena-Manzanares et al. [33] emphasised the importance of top management grasping BIM at an early stage, as it serves to connect all parties involved in a project (S1). Othman et al. [34] suggested that participating in workshops or seminars could support the implementation of BIM (S2). Senior management support is crucial for the successful implementation of BIM in project groups (S3) [33]. Syed Jamaludin [35] recommended that government enforcement could be instrumental in advancing the application of BIM strategies in construction projects (S4). Standardised BIM guidelines among government agencies overseeing different stakeholders are essential (S5) [36]. Zaini et al. [37] identified some strategies, such as a strategic approach model to help BIM implementation in construction players (S6), and stressed the collaboration of BIM stakeholders, academia, and researchers to familiarise students with BIM in education institutions (S7).

3. Methodology

In stage 1, the problem statement and research objectives were meticulously defined. A quantitative approach was chosen due to practical factors like time constraints, resource availability, and accessibility, in line with positivist principles. The target population for the research consists of quantity surveyors who work in consulting firms in Malaysia. The research employs both primary and secondary data collection methods, with the primary data involving quantitative data collected through surveys. Quantitative data is defined as the primary data, while the literature review is categorised as secondary data.

In Stage 2, the questionnaire design was divided into four sections. Section A explores respondents' backgrounds, including their education level, employment status, years of experience in QSP firms, and current use of BIM in their respective firms. Section B prompts respondents to assess BIM capabilities in QSP. Section C focuses on respondents rating the challenges associated with BIM adoption within QSP. Lastly, Section D asks respondents to rate BIM implementation strategies in QSP. A six-point Likert scale will be used for sections B, C and D, with options ranging from strongly disagree to strongly agree. The selection of a six-point Likert scale is to avoid a neutral midpoint, thus encouraging respondents to make a positive or negative response [38]. Following the questionnaire design, a pretest was conducted with five experienced lecturers in BIM or quantity surveying courses from Malaysian higher education institutions. It was discovered from the pretest results that certain

English phrases required restructuring for better clarity. Consequently, the questionnaire was revised and is now ready for distribution.

The population considered in this study comprises the number of Registered Consultant QSs in Klang Valley. The sample selection follows a similar approach to previous studies [39]. Based on the Board of Quantity Surveyors Malaysia [40], there are approximately 243 registered practices in this region. To calculate the sample size, Slovin's formula [41] was used as shown in equation (1).

$$n = \frac{N}{1+Ne^2} \quad (1)$$

$$n = \frac{243}{1 + 243(0.05)^2} = 151 \approx 150$$

where N = population (243) and e = margin error (5%)

A total of 150 questionnaires were randomly distributed through email and social media platforms to selected QS consulting firms and registered QSs. By the survey deadline, 120 responses had been collected, resulting in an 80% response rate. This rate exceeded the range reported by Lund [42], where response rates for similar studies typically fluctuate between 16.5% and 50%, with a median of 27.8%.

In Stage 3, the data collection will be analysed using IBM Statistical Package for Social Sciences (SPSS) software, which is a comprehensive system for data analysis. The analysis will employ two statistical methods, which are reliability and descriptive analyses. For the reliability analysis, Cronbach's alpha will be assessed for each section of the questionnaire to evaluate its internal consistency. For the descriptive analysis, several metrics will be assessed, including mean, standard deviation, relative importance index (RII) and ranking. All of these metrics can be evaluated in SPSS, except for RII. The RII was particularly useful for questionnaires that use a Likert scale. The RII formula [43] was applied in Microsoft Excel to calculate the index for sets of objects, as shown in equation (2).

$$RII = (n_{sD} + 2n_D + 3n_{SD^1} + 4n_{SA^1} + 5n_A + 6n_{sA})/AN \quad (2)$$

where n_{SD} represents the number of respondents for Strongly Disagree until n_D represents the number of respondents for strongly disagree, n_D represents the number of respondents for disagree, n_{SD^1} represents the number of respondents for slightly disagree, n_{SA^1} represents the number of respondents for slightly agree, n_A represents the number of respondents for agree, and n_{SA} represents the number of respondents for strongly agree. A represents the highest scale (6), and N represents the total sample size (120). The possible RII values are between 0 and 1 (exclusive of 0); the higher the RII, the more important the factor. Next, conceptual framework is developed based on the top three results to address the research gap in this study. Figure 1 illustrates a general flowchart of research methodology. The subsequent section will provide a detailed discussion of the results and findings derived from the administered questionnaires.

4. Results

4.1 Reliability test

A reliability analysis was conducted to measure internal consistency across each construct. The values of Cronbach's alpha for the capabilities construct (11 items), challenges construct (8 items), and strategies construct (7 items) are 0.833, 0.825 and 0.870, respectively. When considering all three constructs together, the total of 26 items achieved a Cronbach's alpha of 0.895. It is noted that all Cronbach's alpha values exceeded the minimum threshold of 0.7, indicating that all the constructs are consistent and reliable [44].

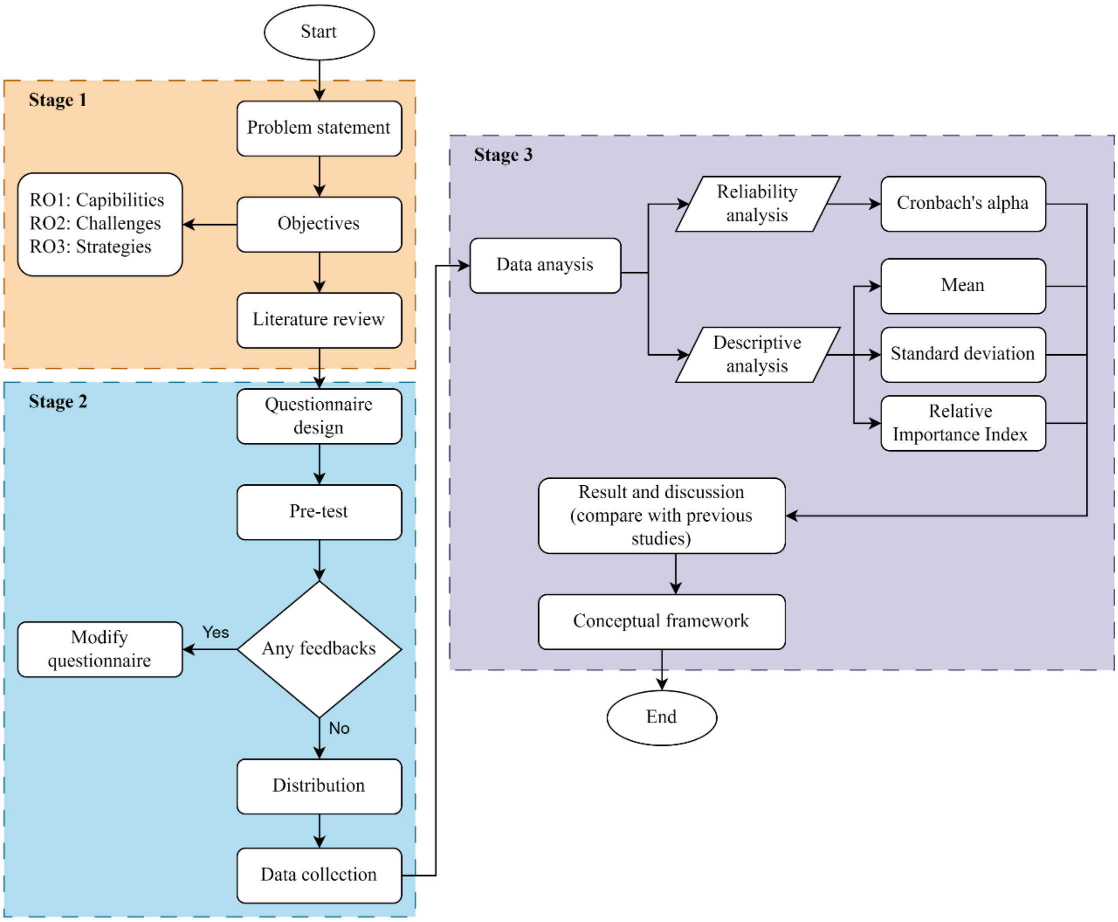

Figure 1. A general flowchart of research methodology

4.2 Demographic profile

Figure 2 represents the qualifications of the respondents working as QSs in Klang Valley, Malaysia. The findings reveal that the largest portion of respondents, constituting 71.7% (86 respondents), hold a bachelor's degree. The second highest qualification is a Diploma, equivalent to 22.5% (27 respondents). Finally, the smallest group consists of master's degree holders, representing 5.8% (7 respondents).

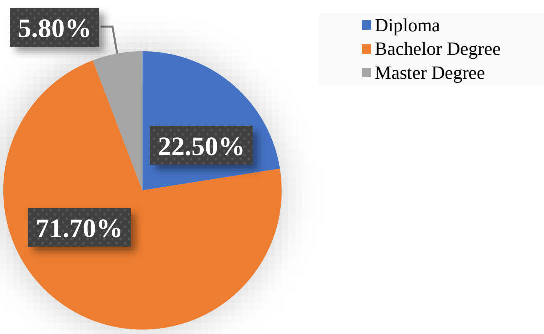

Figure 2. Respondent's qualification

Figure 3 represents the respondent's positions within the firm, and the findings indicate that the majority of respondents hold the role of quantity surveyor, constituting 57.5% (69 respondents). The position of assistant quantity surveyor constitutes the second-highest proportion, accounting for 29.2% (37 respondents). Additionally, there are 7 directors and 6 project managers, both accounting for 5.8% and 5.0%, respectively, with closely aligned percentages. Lastly, the smallest group of respondents comes from contract managers, representing 2.5% (3 respondents).

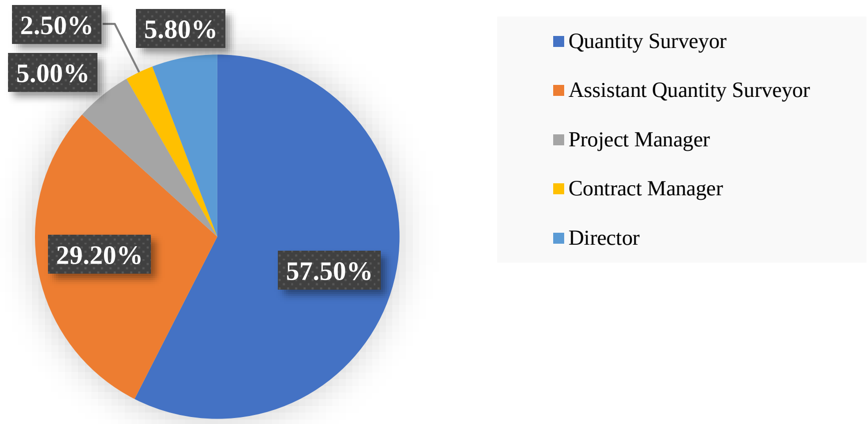

Figure 3. Respondent's position in the firm

Figure 4 represents the respondent's working experience, and the findings highlight that the majority of respondents have been working in the 6 to 10 years range, constituting 54.2% (65 respondents). The second-highest proportion is represented with less than 5 years of working experience, accounting for 30.8% (37 respondents). There are 9 respondents each in the 11 to 15 years range and the more than 15 years range, both contributing 7.5% and displaying identical percentages. This indicates that most half of the respondents are at a critical stage in their careers where they have sufficient industry exposure to understand current practices and challenges while being adaptable to adopting new technologies like BIM.

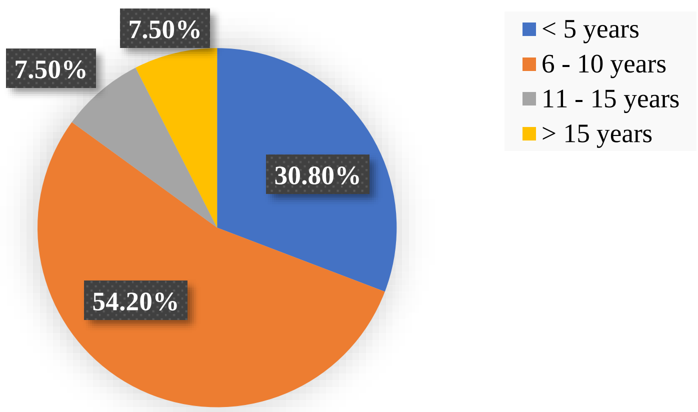

Figure 4. Respondent's working experience

4.3 Descriptive analysis: BIM capabilities

Table 1 presents the ranking of overall BIM capabilities. The data analysis shows that the highest ranking was C4: Easily refines cost plans with evolving design details (M = 5.43±0.629, RII = 0.906), followed by C10: Consistently reflects design changes across all views (M = 5.43±0.771, RII = 0.906). Although both capabilities shared the same mean and RII values, the difference in their standard deviations was used to distinguish the first and second rankings. C6: Clash detection minimises design errors and cost estimate revisions (M = 5.19±0.699, RII = 0.865). was ranked third. Lastly, the lowest ranking was C5: Centralises storage of data in a coordinated model by an intelligent information management system (M = 4.44±1.079, RII = 0.740). According to the Likert scale data, more than 85% of the respondents agreed with all statements, except for C5, where 23% of respondents expressed slight disagreement with this particular capability.

Table 1: Ranking of overall BIM capabilities

No.	BIM Capabilities	SD	D	SD1	SA1	A	SA	Mean	Std. deviation	RII	Ranking
C4	Easily refines cost plans with evolving design details	0	0	1	6	53	60	5.43	0.629	0.906	1
C10	Consistently reflects design changes across all views	0	0	4	9	38	69	5.43	0.771	0.906	2
C6	Clash detection minimises design errors and cost estimate revisions	0	0	3	11	66	40	5.19	0.699	0.865	3
C9	Automatically quantifies items for the preparation of Bill of Quantities (BoQ)	0	0	4	19	49	48	5.18	0.813	0.863	4
C1	Quick preparation of cost appraisals at the feasibility stage	0	0	1	24	49	46	5.17	0.767	0.861	5
C2	Generates a preliminary cost plan by directly extracting quantities from the model	0	0	3	16	60	41	5.16	0.742	0.860	6
C3	Effortlessly produces precise cost estimation for different design options	0	0	3	34	41	42	5.02	0.856	0.836	7
C11	Enhances visualisation for a clearer understanding of designs	0	0	3	44	30	43	4.94	0.772	0.824	8
C8	Rapid cost checking ensures the inclusion of all items	0	0	3	43	33	41	4.93	0.891	0.822	9
C7	Effortlessly produces the cost impact of design alterations without manual remeasurement	0	0	13	57	18	32	4.58	0.997	0.763	10
C5	Centralises data storage in a coordinated model by an intelligent information management system	0	0	27	41	24	28	4.44	1.079	0.740	11

*SD = Strongly disagree; D = Disagree; SD1 = Slightly disagree; SA1 = Slightly agree; A = Agree; SA = Strongly agree

4.4 Descriptive analysis: Challenges

Conventional QSP effective in many aspects, but they do face several challenges, as outlined in Table 2. The table presents the ranking of challenges encountered with conventional QSP, ranging from the highest mean of 5.44 to the lowest of 4.84. The highest ranking was P7: Non-standardised documentation formats (M = 5.44±0.814, RII = 0.907). The second highest was P2: Remeasurement (M = 5.37±0.865, RII = 0.894). The third highest ranking was attributed to P6: Misalignment in communication among architectural, structural, and M&E drawings (M = 5.27±0.793, RII = 0.878). Lastly, the lowest ranking was assigned to P3: Under or over measurements (M = 4.84±0.983, RII = 0.807). According to the Likert scale data, all respondents expressed agreement with all the statements.

Table 2: Ranking of challenges encountered by BIM with conventional QSP

No.	Challenges	SD	D	SD[1]	SA[1]	A	SA	Mean	Std. deviation	RII	Ranking
P7	Non-standardised documentation formats	0	1	2	13	31	73	5.44	0.814	0.907	1
P2	Remeasurement	0	2	2	13	36	67	5.37	0.865	0.894	2
P6	Misalignment in communication among architectural, structural, and M&E drawings	0	0	7	5	57	51	5.27	0.793	0.878	3
P1	Conventional measurement approaches	0	0	3	26	37	54	5.18	0.856	0.864	4
P4	Re-estimation	0	0	2	25	48	45	5.13	0.795	0.856	5
P8	Using obsolete and unsupported software	0	2	4	33	29	52	5.04	0.995	0.840	6
P5	Misinterpretation of information related to the drawings	0	0	2	52	23	43	4.89	0.920	0.815	7
P3	Under or over measurements	0	1	5	48	24	42	4.84	0.983	0.807	8

4.5 Descriptive analysis: Strategies

Table 3 outlines the ranking of overall strategies for implementing BIM in QSP. The data analysis shows that the highest ranking was S1: Early comprehension of top management in an organisation (M = 5.26±0.926, RII = 0.876). The second highest ranking was S2: Enhancing BIM awareness through training and participation in related seminars (M = 5.10±0.723, RII = 0.850). The third highest ranking strategy was S6: A strategic approach model is needed for contractors to facilitate the implementation of BIM in construction projects (M = 4.88±0.962, RII = 0.813). Lastly, the lowest ranking was assigned to S7: Collaboration among BIM practitioners, academia, and researchers to educate and introduce BIM to undergraduate and postgraduate students in Malaysian institutions (M = 4.53±1.190, RII = 0.756). It is noted that more than 95% of respondents agreed with S1, S2, S4 and S6, while 25% expressed slight disagreement with S3, S5 and S7.

Table 3: Ranking of implementation strategies

No	Strategies	SD	D	SD[1]	SA[1]	A	SA	Mean	Std. deviation	RII	Ranking
S1	Early comprehension of BIM by top management in an organisation	0	1	1	31	20	67	5.26	0.926	0.876	1
S2	Enhancing BIM awareness through training and participation in related seminars	0	1	4	8	76	31	5.10	0.723	0.850	2

S6	A strategic approach model is needed for contractors to facilitate the BIM implementation of BIM in construction projects	0	0	3	55	16	46	4.88	0.962	0.813	3
S5	The government should issue guidelines for BIM	0	0	29	20	7	64	4.88	1.286	0.814	4
S3	Senior management in the organisation should actively endorse the implementation of BIM	0	0	28	22	13	57	4.83	1.249	0.804	5
S4	Government enforcement of BIM implementation in construction projects	0	0	0	60	26	34	4.78	0.858	0.797	6
S7	Collaboration among BIM practitioners, academia, and researchers to educate and introduce BIM to undergraduate and postgraduate students in Malaysian institutions	0	0	29	39	11	41	4.53	1.190	0.756	7

*SD = Strongly disagree; D = Disagree; SD1 = Slightly disagree; SA1 = Slightly agree; A = Agree; SA = Strongly agree

5. Discussions

Table 4 compares the top three BIM capabilities, challenges and strategies with other developing countries. All the studies are in quantity surveying discipline to ensure relevance of the findings.

Table 4: Comparative ranking of BIM capabilities, challenges and strategies

Capabilities Ranking	**Malaysia (Current research)**	**Nigeria [45]**	**South Africa [46]**
1st	Easily refines cost plans with evolving design details	Faster generation of quantity take-off	Improved communication
2nd	Consistently reflects design changes across all views	Ease of pre-estimation	Improved visualisation
3rd	Clash detection minimises design errors and cost estimate revisions	Better design management through easy detection of design clashes	Automatic quantities
Challenges Ranking	**Malaysia (Current research)**	**Nigeria [47]**	**South Africa [48]**
1st	Non-standardised documentation formats	High cost of BIM packages	Lack of BIM expertise
2nd	Remeasurement	Lack of client demand for BIM	Lack of government enforcement
3rd	Misalignment in communication among architectural, structural, and M&E drawings	Limited access to useful BIM objects	Resistance to change
Strategies Ranking	**Malaysia (Current research)**	**Nigeria [49]**	**Sri Lanka [50]**

1st	Early comprehension of BIM by top management in an organisation	Conduct training workshops and seminars by regulators	Implement BIM regulations and a National Action Plan
2nd	Enhancing BIM awareness through training and participation in related seminars	Learn new BIM contractual aspects	Lead adoption through public projects
3rd	A strategic approach model is needed for contractors to facilitate the BIM implementation of BIM in construction projects	Train in BIM management functions	Organise seminars, workshops and short courses

For BIM capabilities in Malaysian QSP, automation features such as quantity take-offs and clash detection are highly valued. These capabilities highlight the increasing reliance on BIM to improve precision and operational efficiency in the QSP. However, different countries have different needs. In Malaysia, cost management stands out as the main area of focus because the local industry places a strong emphasis on risk mitigation and financial accuracy. Conversely, Nigeria prioritises efficiency and speed in order to meet the need for quick decisions and efficient procedures. To address the need for improved stakeholder communication and project comprehension, South Africa places a strong emphasis on collaboration and visualisation. Thus, the ability to update cost plans with design changes was important in Malaysia when compared to other contexts as it allows the BIM software to automatically update cost plans with changes in design, removing any work involved in manually re-measuring this process [51].

For challenges with conventional Malaysian QSP, Malaysia faces technical barriers such as documentation formats and communication issues, whereas Nigeria grapples with cost and resource availability. On the other hand, South Africa's challenges centre around expertise and policy enforcement. For Malaysia, there should be a set of clear guidelines to be followed and standardised steps to implement BIM technology in projects [30], or else it may cause limitations in applying the new technology and become a quandary for QSs if BIM is fundamentally expected in construction projects [15]. Furthermore, the implementation of BIM in Malaysia was challenged by the requirement for collaboration among consultants from different companies and backgrounds. This challenge was exacerbated by the lack of exposure to BIM in the Malaysian construction industry, therefore communication impediments among QSs and other professional construction players [52].

Common themes such as training and workshops were identified for BIM implementation strategies in Malaysia, Nigeria and Sri Lanka. But their focuses are different. For example, while Nigeria depends on regulatory-driven training and Sri Lanka places more emphasis on government-led regulations and public project implementation, Malaysia emphasises top management involvement and strategic approaches for contractors. Therefore, Malaysia should keep putting top management support while developing tailored frameworks to guide QSs in BIM adoption. A supported study by Siebelink et al. [53] identified that a key obstacle in reaching higher levels of BIM maturity was the lack of substantial support from top management. Strong top management support is a must for organisations with high BIM maturity levels such as 5D BIM (costing). Those supports include providing clear communication about what BIM is and how its benefits can boost BIM implementation.

According to the results, the top three ranking items of each construct were selected to develop a conceptual framework for this research. The interactions of these components within the framework are depicted in Figure 5 to show how these components are interdependent from each other and act as an overall structure of the model. This framework follows the Attract-Convert-Close-Delight model, a systematic approach for guiding stakeholders from the initial awareness stage to becoming advocates for its implementation. The involvement of government bodies like Construction Industry Development Board (CIDB), and industry associations such as Pertubuhan Akitek Malaysia (PAM) and Royal Institution of Surveyors Malaysia (RISM), are influential in driving BIM awareness and certification across the Malaysian construction industry. Their roles span multiple sectors to provide contractors, architects and QSs with equipped knowledge and tools needed for successful BIM integration. This framework for BIM implementation aligns with the Malaysia Strategic Plan 2021-2025.

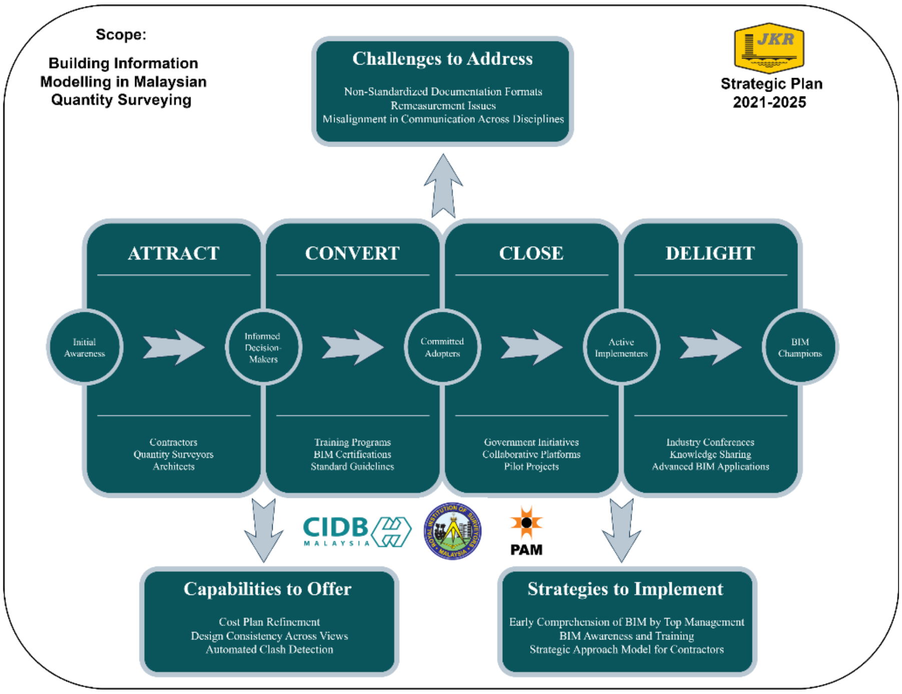

Figure 5. A conceptual framework for BIM implementation in Malaysian Quantity Surveying

6. Conclusions

This research investigated BIM capabilities in Malaysian QSP, addressed the challenges associated with conventional QSP, and proposed strategies for effective BIM implementation within this context. All the data in this research were reliable. Research objective 1 was achieved by identifying capabilities that easily refine cost plans with evolving design details, consistently reflect design changes across all views, and enable clash detection to minimise design errors and cost estimate revisions. For research objective 2, the findings acknowledged the challenges of conventional Malaysian QSP, which included non-standardised documentation formats, remeasurement issues and misalignment in communication among architectural, structural and M&E drawings. Additionally, for research objective 3, the strategies to enhance BIM implementation in Malaysian QSP were early comprehension of BIM by top management in an organisation, enhancing BIM awareness through training and participation in related seminars, and developing a strategic approach model for BIM implementation in construction projects. Most smaller firms in Malaysia remain loyal to conventional methods because they cannot afford to adopt BIM technology due to the involvement of supplementary costs. The company must incur additional expenses to provide training for their employees and hire new staff with BIM expertise during the shift to a different workplace. The research does not show any indication that QSP has a negative attitude towards BIM, that the importance of quantity surveying tasks diminishes in BIM, that BIM will lead to a new set of skills replacing current QSs, or that QSs will become less appealing in the future due to BIM.

For academic contribution, the research provides empirical data and insights that fill gaps in current literature, particularly concerning the Malaysian context. Also, by identifying key capabilities, challenges and strategies, this research sets the benchmark for more in-depth studies and comparative analyses across different regions and construction sectors. For practical contribution, a proposed conceptual framework can be used by quantity surveying firms to develop targeted BIM adoption plans. The research also provides QS with concrete methods to enhance their efficiency and accuracy.

It is imperative to acknowledge the limitations of this research, particularly the geographical scope confined to Kuala Lumpur and Selangor. Due to the lack of precise data on the quantity of surveyors proficient in BIM, it was challenging to determine a saturation point. Moreover, BIM design and cost management applications are still in the early stages, and the level of commitment to it varies greatly from one firm to another, as they are largely just using BIM for replicating their traditional fragmented processes. It should be noted in closing that this study did not cover the levels of maturity in firms' BIM implementation.

Future research endeavours could consider expanding the scope to regions like Penang and Johor which are characterised by high levels of construction development in order to attain a more comprehensive perspective. Using technology adoption theories such as Technology Acceptance Model (TAM), Technology-Organisation-Environment (TOE), or Unified Theory of Acceptance and Use of Technology) (UTAUT) to study users' perceptions of 5D BIM usage in QSP in the Malaysian construction industry would yield valuable insights into the determinants influencing BIM adoption and its effective implementation. Furthermore, by adopting a mixed-method approach (quantitative and qualitative research), future investigations could be enriched by accommodating diverse viewpoints and validating the findings.

Acknowledgements

The authors wish to express their sincere gratitude to Universiti Teknologi Malaysia (UTM) for their invaluable support and funding, which made this research possible. This work was funded by the Universiti Teknologi Malaysia Encouragement Research under Reference No: PY/2023/01015, with the Cost Center: Q.J130000.3822.31J98. The support provided by UTM significantly contributed to the successful completion of this research.

References

[1] O. Doukari, B. Seck, and D. Greenwood, "The efficient generation of 4D BIM construction schedules: A case study of the Nanterre 2 CESI project in France," *Frontiers in Built Environment,* vol. 8, 2022. doi: https://doi.org/10.3389/fbuil.2022.998309

[2] R. Charef, H. Alaka, and S. Emmitt, "Beyond the Third Dimension of BIM: A Systematic Review of Literature and Assessment of Professional Views," *Journal of Building Engineering,* vol. 19, pp. 242-257, 2018. doi: https://doi.org/10.1016/j.jobe.2018.04.028

[3] O. Olugboyega and A. Windapo, "Investigating the strategic planning of BIM adoption on construction projects in a developing country," *Journal of Construction in Developing Countries,* vol. 27, no. 2, pp. 183-204, 2022. doi: https://doi.org/10.21315/jcdc-02-21-0031

[4] L. Liao, E. A. Teo, R. Chang, and X. Zhao, "Diffusion of Building Information Modeling in Building Projects and Firms in Singapore," *Sustainability*, vol. 12, no. 18, p. 7762, 2020. doi: https://doi.org/10.3390/su12187762

[5] S. O. Babatunde, C. Udeaja, and A. O. Adekunle, "Barriers to BIM implementation and ways forward to improve its adoption in the Nigerian AEC firms," *International Journal of Building Pathology and Adaptation,* vol. 39, no. 1, pp. 48-71, 2021. doi: https://doi.org/10.1108/IJBPA-05-2019-0047

[6] R. S. Shojaei, K. Oti-Sarpong, and G. Burgess, "Leading UK Construction Companies' Strategies to Tackle BIM Training and Skills Challenges," *International Journal of Construction Education and Research,* vol. 19, no. 4, pp. 383-404, 2023. doi: https://doi.org/10.1080/15578771.2022.2123071

[7] P. Wu, R. Jin, Y. Xu, F. Lin, Y. Dong, and Z. Pan, "The analysis of barriers to bim implementation for industrialized building construction: A China

study," *Journal of Civil Engineering and Management,* vol. 27, pp. 1-13, 2021. doi: http://doi.org/10.3846/jcem.2021.14105

[8] CIDB, "Malaysia Building Information Modeling (BIM) Report 2021," in "BIM in Malaysia Construction Industry," 2021.

[9] J. Spellacy, D. J. Edwards, C. J. Roberts, S. Hayhow, and M. Shelbourn, "An investigation into the role of the quantity surveyor in the value management workshop process," *Journal of Engineering, Design and Technology,* vol. 19, no. 2, pp. 423-445, 2021. doi: https://doi.org/10.1108/JEDT-07-2020-0289

[10] R. Assaad, H. El-Adaway Islam, and S. Abotaleb Ibrahim, "Predicting Project Performance in the Construction Industry," *Journal of Construction Engineering and Management,* vol. 146, no. 5, p. 04020030, 2020. doi: http://doi.org/10.1061/(ASCE)CO.1943-7862.0001797

[11] L.-C. Mara, I. Brunet Icart, and J. Cabré Olivé, "Innovation Skills Training in a Lifelong Learning Programme for Unemployed People, in Catalonia (Spain)," *Innovation: The European Journal of Social Science Research,* pp. 1-15, 2020. doi: https://doi.org/10.1080/13511610.2020.1774353

[12] N. A. A. Ismail, H. Adnan, and n. a. Bakhary, "Building Information Modelling (BIM) Adoption by Quantity Surveyors: A Preliminary Survey from Malaysia," 2019. doi: https://doi.org/10.1088/1755-1315/267/5/052041

[13] O. A. Olatunji, J. J. S. Lee, H.-Y. Chong, and A. A. Akanmu, "Building information modelling (BIM) penetration in quantity surveying (QS) practice," *Built Environment Project and Asset Management,* vol. 11, no. 5, pp. 888-902, 2021. doi: https://doi.org/10.1108/BEPAM-08-2020-0140

[14] L. T. Soon, B. T. Leong, F. L. Ang, and H. Hassan, "A Preliminary BIM Implementation Framework for Consultant Quantity Surveyor Firms in A Developing Country," 2016.

[15] N. A. A. Ismail, M. N. M. Yousof, and H. Adnan, "BIM adoption in managing construction risks amongst Malaysian quantity surveyors: current practice and challenges," *International Journal of Sustainable Construction Engineering and Technology,* vol. 12, no. 3, pp. 166-175, 2021. doi: http://doi.org/10.30880/ijscet.2021.12.03.017

[16] S.-W. Yang, S.-W. Moon, H. Jang, S. Choo, and S.-A. Kim, "Parametric Method and Building Information Modeling-Based Cost Estimation Model for Construction Cost Prediction in Architectural Planning," *Applied Sciences*, vol. 12, no. 19, p. 9533, 2022. doi: https://doi.org/10.3390/app12199553

[17] M. Lee, C. Chai, Y. Xiong, and H. Gui, "Technology acceptance model for Building Information Modelling Based Virtual Reality (BIM-VR) in cost estimation," *Journal of Information Technology in Construction,* vol. 27, pp. 914-925, 2022. doi: http://doi.org/10.36680/j.itcon.2022.044

[18] H. Alzraiee, "Cost estimate system using structured query language in BIM," *International Journal of Construction Management,* vol. 22, no. 14, pp. 2731-2743, 2022. doi: https://doi.org/10.1080/15623599.2020.1823061

[19] H. T. T. Le, V. Likhitruangsilp, and N. Yabuki, "A BIM-Database-Integrated System for Construction Cost Estimation," *ASEAN Engineering Journal,* vol. 11, no. 1, pp. 45-59, 2021. doi: https://doi.org/10.11113/aej.v11.16666

[20] W. N. S. Wan Mohammad and N. N. Mohd Azmi, "Building Information Modeling (BIM)-Based Information Management Platform in the Construction Industry," *International Journal of Academic Research in Business and Social Sciences,* vol. 13, no. 4, pp. 1957-1967, 2023. doi: http://doi.org/10.6007/IJARBSS/v13-i4/16922

[21] M. R. Elyano and Yuliastuti, "Analysis of clash detection and quantity take-off using BIM for warehouse construction," *IOP Conference Series: Earth and Environmental Science,* vol. 794, p. 012012, 2021. doi: http://doi.org/10.1088/1755-1315/794/1/012012

[22] C. Gilchrist, R. Cumberlege, and C. Allen, "Lack of implementing Building Information Modelling in the quantity surveying profession," *IOP Conference Series: Earth and Environmental Science,* vol. 654, p. 012025, 2021. doi: http://doi.org/10.1088/1755-1315/654/1/012025

[23] J. Farooq, S. R, and P. Sharma, "A BIM-based Detailed Electrical Load Estimation, Costing and Code Checking," *International Journal of Electrical and Computer Engineering,* vol. 8, pp. 3484-3495, 2018. doi: http://doi.org/10.11591/ijece.v8i5.pp3484-3495

[24] B. Sherafat, H. Taghaddos, and E. Shafaghat, "Enhanced Automated Quantity Take-Off in Building Information Modeling Enhanced automated quantity take-off in building information modeling," *Scientia Iranica,* vol. 29, no. 3, pp. 1024-1037, 2022.

[25] V. Moayeri, O. Moselhi, and Z. Zhu, "Design Change Management Using BIM-based Visualization Model," *International Journal of Architecture, Engineering and Construction,* vol. 6, 2017.

[26] H. Salleh, A. A. Ahmad, Z. Abdul-Samad, W. S. Alaloul, and A. S. Ismail, "BIM Application in

Construction Projects: Quantifying Intangible Benefits," *Buildings*, vol. 13, no. 6, p. 1469, 2023. doi: https://doi.org/10.3390/buildings13061469

[27] Z. Zhan, Y. Tang, C. Wang, J. B. H. Yap, and Y. S. Lim, "System Dynamics Outlook on BIM and LEAN Interaction in Construction Quantity Surveying," *Iranian Journal of Science and Technology, Transactions of Civil Engineering,* vol. 46, no. 5, pp. 3947-3962, 2022. doi: https://doi.org/10.1007/s40996-022-00833-w

[28] K. A. A. Jamal, Cheah Shu Ee, Noor Azeyah Khiyon, and N. A. A. Wahab, "Scan-to-BIM Approach Towards Producing Quantity Take-off of Heritage Buildings in Malaysia," *Journal of Engineering Science and Technology,* pp. 120-137, 2021.

[29] F. Tahmasebinia and V. Song, "Significant Factors Causing Delay in the Cambodian Construction Industry," *Sustainability*, vol. 14, no. 6, p. 3521, 2022. doi: https://doi.org/10.3390/su14063521

[30] N. Zainon, F. A. Mohd-Rahim, N. M. Aziz, S. N. Kamaruzzaman, and S. Puidin, "Catching up with building information modeling: challenges and opportunities for quantity surveyors," *Journal of Surveying, Construction and Property,* vol. 9, no. 1, pp. 19-31, 2018. doi: http://doi.org/10.22452/jscp.vol9no1.3

[31] A. M. Farouk, A. Z. Zulhisham, Y. S. Lee, M. S. Rajabi, and R. A. Rahman, "Factors, Challenges and Strategies of Trust in BIM-Based Construction Projects: A Case Study in Malaysia," *Infrastructures*, vol. 8, no. 1, p. 13, 2023. doi: https://doi.org/10.3390/infrastructures8010013

[32] N. S. M. Azizi, Z. Y. Tan, and Z. Azizi, "Preliminary study of changes in work practices of quantity surveyors in building information modelling (BIM) projects," *International Journal of Sustainable Construction Engineering and Technology,* vol. 12, no. 1, pp. 140-152, 2021. doi: https://doi.org/10.30880/ijscet.2021.12.01.014

[33] F. Villena-Manzanares, T. García-Segura, and E. Pellicer, "Organizational Factors That Drive to BIM Effectiveness: Technological Learning, Collaborative Culture, and Senior Management Support," *Applied Sciences*, vol. 11, no. 1, p. 199, 2020. doi: https://doi.org/10.3390/app11010199

[34] I. Othman, Y. Y. Al-Ashmori, Y. Rahmawati, Y. H. Mugahed Amran, and M. A. M. Al-Bared, "The level of Building Information Modelling (BIM) Implementation in Malaysia," *Ain Shams Engineering Journal,* vol. 12, no. 1, pp. 455-463, 2021. doi: https://doi.org/10.1016/j.asej.2020.04.007

[35] S. Z. H. Syed Jamaludin, "The Emerging Challenges of Adopting BIM in the Construction Industry: Evidence from Sabah, Malaysia," *Journal of Smart Science and Technology*, vol. 2, no. 1, pp. 1-14, 2022. doi: https://doi.org/10.24191/jsst.v2i1.19

[36] M. Algahtany, A. R. Radzi, M. S. Al-Mohammad, and R. A. Rahman, "Government Initiatives for Enhancing Building Information Modeling Adoption in Saudi Arabia," *Buildings*, vol. 13, no. 9, p. 2130, 2023. doi: https://doi.org/10.3390/buildings13092130

[37] A. A. Zaini, A. W. Razali, H. C. Gui, N. Zaini, and S. D. Tamjehi, "Assessing Strategies of Building Information Modeling (BIM) Implementation in Sarawak Construction Industry," *IOP Conference Series: Earth and Environmental Science,* vol. 498, no. 1, p. 012086, 2020. doi: https://doi.org/10.1088/1755-1315/498/1/012086

[38] I. Kusmaryono, D. Wijayanti, and H. R. Maharani, "Number of Response Options, Reliability, Validity, and Potential Bias in the Use of the Likert Scale Education and Social Science Research: A Literature Review," *International Journal of Educational Methodology,* vol. 8, no. 4, pp. 625-637, 2022. doi: https://doi.org/10.12973/ijem.8.4.625

[39] N. Razali, N. Khalil, A. A. Mohamad Bohari, and H. N. Husin, "Green Procurement in Construction: Analysis of the Readiness Level and Key Catalyst among Construction Enablers," *International Journal of Sustainable Construction Engineering and Technology,* vol. 12, no. 1, pp. 1-11, 2021. doi: https://doi.org/10.30880/ijscet.2021.12.01.001

[40] B. Board of Quantity Surveyors Malaysia. (2019). Registered Member [Online]. Available: https://www.bqsm.gov.my/en/registered-member/

[41] A. E. Oke, J. Aliu, P. Oluwasefunmi Fadamiro, P. O. Akanni, and S. S. Stephen, "Attaining digital transformation in construction: An appraisal of the awareness and usage of automation techniques," *Journal of Building Engineering,* vol. 67, p. 105968, 2023. doi: https://doi.org/10.1016/j.jobe.2023.105968

[42] B. Lund, "The questionnaire method in systems research: an overview of sample sizes, response rates and statistical approaches utilized in survey studies," *VINE Journal of Information and Knowledge Management Systems,* vol. 53, no. 1, pp. 1-10, 2021. doi: https://doi.org/10.1108/VJIKMS-08-2020-0156

[43] N. S. Azman, M. Z. Ramli, R. Razman, M. H. Zawawi, I. N. Ismail, and M. R. Isa, "Relative importance index (RII) in ranking of quality factors on industrialised building system (IBS) projects in Malaysia," *AIP Conference Proceedings*, vol. 2129, no. 1, 2019. doi: http://doi.org/10.1063/1.5118037

[44] N. Van Tam, N. Quoc Toan, V. V. Phong, and S. Durdyev, "Impact of BIM-related factors affecting construction project performance," *International Journal of Building Pathology and Adaptation,* vol. 41, no. 2, pp. 454-475, 2023. doi: https://doi.org/10.1108/IJBPA-05-2021-0068

[45] O. Ogunseiju, H. A. Odeyinka, and A. O. Yusuf, "Usage of Building Information Modelling in Quantity Surveying Firms in Nigeria," *Journal of Construction Business and Management,* vol. 6, no. 2, pp. 27-37, 2023. doi: https://doi.org/10.15641/jcbm.6.2.1378

[46] C. R. Gilchrist, R. Cumberlege, and C. Allen, "Lack of implementing Building Information Modelling in the quantity surveying profession," *IOP Conference Series: Earth and Environmental Science,* vol. 654, no. 1, p. 012025, 2021. doi: https://doi.org/10.1088/1755-1315/654/1/012025

[47] S. A. Adekunle, C. Aigbavboa, O. Ejohwomu, W. D. Thwala, and N. Efiannayi, "Key constraints to optimal BIM penetration among Nigerian Quantity surveyors," *Construction Management 50th Anniversary Conference*, 2021.

[48] K. Otasowie, C. Aigbavboa, M. Ikuabe, P. Adekunle, A. Oke, and S. Adekunle, "Barriers to the Adoption of Building Information Modeling in Quantity Surveying Practice in South Africa," in *Proceedings of the 31st Annual Conference of the International Group for Lean Construction (IGLC31)*, pp. 41-49, 2023. doi: https://doi.org/10.24928/2023/0137

[49] O. Akinsiku, "The impacts of building information modelling (BIM) on quantity surveying practice," vol. 8, no. 1, 2016.

[50] W. Wijesundara and A. Amarathunga, "Enhancing the effectiveness and efficiency by adopting Building Information Modelling in the service delivery of the Quantity Surveying practice of Sri Lanka," pp. 184-187, 2023.

[51] M.-A. Vigneault, C. Boton, H.-Y. Chong, and B. Cooper-Cooke, "An innovative framework of 5D BIM solutions for construction cost management: a systematic review," Archives of Computational Methods in Engineering, vol. 27, pp. 1013-1030, 2020. doi: https://doi.org/10.1007/s11831-019-09341-z

[52] T. Ying, E. Kamal, and M. Esa, "Building information modelling (BIM) implementation: Challenges for quantity surveyors," Int. Trans. J. Eng. Manag. Appl. Sci. Technol, vol. 13, pp. 1-10, 2022.

[53] S. Siebelink, H. Voordijk, M. Endedijk, and A. Adriaanse, "Understanding barriers to BIM implementation: Their impact across organizational levels in relation to BIM maturity," Frontiers of Engineering Management, vol. 8, no. 2, pp. 236-257, 2021. doi: https://doi.org/10.1007/s42524-019-0088-2