Available online at
http://journal.uitm.edu.my/ojs/index.php/BEJ

e-ISSN: 2637-0395

Built Environment Journal 21(Special Issue) 2024, 93 – 103.

Built Environment Journal

The Implementation of 5D BIM in Construction Management: Benefits and Challenges Faced by Construction Professionals

Nur Dalisya Humaira Mohd Saupi[1], Noor Akmal Adillah Ismail[1*]

[1] *School of Construction and Quantity Surveying, College of Built Environment, 40450 Shah Alam Selangor, Malaysia*

ARTICLE INFO

Article history:
Received 24 July 2024
Revised 30 August 2024
Accepted 30 August 2024
Online first
Published 30 September 2024

Keywords:
Building Information Modelling
BIM
5D BIM
Construction Management
Construction Industry

DOI:
10.24191/bej.v21iSpecial Issue.2418

ABSTRACT

The rapid evolution of technology necessitates integrating new tools within educational curricula, especially in fields like technical and construction education. Building Information Modelling (BIM) is one such advanced technology that has been increasingly adopted by universities worldwide to enhance Architecture, Engineering, and Construction (AEC) programs. BIM facilitates the creation of digital information models, significantly benefiting construction management through improved design comprehension, quantity take-off, and cost estimation. Among its advancements, 5 Dimensional (5D) BIM stands out by enabling users to visualise the impact of design changes on both project cost and timeline. However, its usage is still at the infancy level due to some issues. This paper examines the benefits and challenges of integrating 5D BIM into construction management within the Malaysian construction industry. Data were gathered via an online survey targeting contractors, consultants, and developers, and further analysed using SPSS Average Index (AI). Findings reveal that 5D BIM is highly valued for optimizing time management, enhancing quality control, and improving cost estimation. Nevertheless, significant challenges hinder its broader adoption, including a lack of training and expertise, integration difficulties with existing workflows, technical limitations, and lack of acceptance and standardisation of 5D BIM practice. By addressing these challenges, the construction industry in Malaysia can better harness the potential of 5D BIM, leading to enhanced project efficiency and productivity.

[1*] Corresponding author. *E-mail address*: noorakmal@uitm.edu.my

INTRODUCTION

In today's rapidly evolving construction and technical education landscape, it is crucial for universities to incorporate new technologies into their curricula to stay current and relevant. One of the most significant advancements in the construction industry is Building Information Modelling (BIM), a technology that creates digital information models and is increasingly being integrated into Architecture, Engineering, and Construction (AEC) fields around the world (Gohil et al., 2022). Many educational institutions have recognised the growing industry demand for construction players with BIM skills, prompting the inclusion of BIM in their academic offerings. Previous research has highlighted the benefits of integrating BIM into construction management curricula, emphasizing its effectiveness as a teaching tool for quantity take-off, construction estimating, and enhancing the understanding of building materials, methods, and processes (Mustafa et al., 2023).

BIM is not only a powerful tool for creating digital models but also a vital technology for the coordination, integration, and management of information throughout a project's lifecycle. It allows for the visualisation of construction sequences and the management of both functional and physical qualities of buildings, providing stakeholders with a clear understanding of project development (Katke, 2020). The various dimensions of BIM enable the analysis of multiple aspects of a project before execution, potentially saving time during the building phase by improving response time to design modifications. However, while some studies suggest that BIM can shorten overall project durations, others argue that the time savings are more apparent during the construction phase rather than during the design stage (Kong et al., 2020).

One of the most advanced applications of BIM is 5 Dimensional (5D) BIM, which incorporates cost data into the digital model, allowing users to assess how changes in design elements impact not only the aesthetics of a project but also its cost and construction timeline. The integration of financial data within the information model is central to 5D BIM, enabling more accurate budgeting and cost management throughout a project's lifecycle (Nast & Koch, 2023). By utilizing a BIM-oriented approach and adhering to specific data management protocols, project teams can extract quantitative information from the model to forecast costs, plan cash flows, and allocate resources effectively (Noviani et al., 2022; Hathiwala & Pitroda, 2021).

Despite the widespread adoption of BIM, there remains a significant research gap in understanding the practical benefits and challenges associated with 5D BIM implementation. While earlier dimensions of BIM 3 Dimensional (3D) and 5 Dimensional (4D) have been extensively studied, the specific impacts of integrating cost data through 5D BIM are not well documented. This study aims to bridge this gap by exploring how 5D BIM is currently being implemented in the construction industry, focusing on the perceived benefits and challenges faced by construction professionals. Through this exploration, the study seeks to enhance an understanding of 5D BIM's effectiveness and identify areas where further advancements or support are needed to optimise its use in construction projects.

LITERATURE REVIEW

The construction industry is moving toward the adoption of innovative strategies for efficient work management throughout the lifecycle of the building. Generally, the construction industry is a vital part of estimation necessitating the formation of project techniques. Despite the benefits of large-scale construction enterprises gradually emerging, low management efficiency, low profitability, backward construction management and risk response-ability, no delivery project of expert, poor time scheduling delivered ahead of construction timings, and other factors are common (Gohil et al., 2022).

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

Benefits of 5D BIM in Construction Management

BIM relies on teamwork and, ideally, the usage of a central model where design modifications are automatically updated and coordinated among the project team. There are two ways to achieve collaboration: the first is for project teams to use model software from a single vendor that has all pertinent design and cost data. The second strategy involves using proprietary or open-source software from many manufacturers, which includes measures to ensure that data is completely interchangeable (Azhar, 2011). The model can be shared amongst different professions including architects, engineers, and other consultants because the program can be used by several departments. This enables electronic suggestions and real-time changes to be made during building (Althea & Balakumar, 2018).

More specifically, the users who can view and interact with the 3D model would benefit from visualisation because it will help them better comprehend the project they are working on. For example, Quantity Surveyors can reduce the number of design assumptions they make by viewing the building in 3D from any angle (Samphaongoen, 2010). Adding benefits to this, the 5D method of cost management promotes teamwork on projects and helps with overall project management. Effective 5D requires designers to replicate appropriate 3D data, which the construction crew must then review for inconsistencies. Furthermore, 5D software can check for conflict identification, further fostering a collaborative environment (Althea & Balakumar, 2018).

BIM can simplify work since it can process enormous amounts of data quickly. When necessary, the data can be used to calculate the costs of the products that were measured using just one piece of software. One advantage of these cost-effective, integrated databases is that all pertinent data is kept in one place (Samphaongoen, 2010). Having the capability to gather quantities from the BIM model speeds up the process of creating cost plans, but doing so is exceedingly difficult because the model contains incorrect data, and operating the resource frequently calls for a specialist. At this point, 5D was more efficient than the conventional 2 Dimensional (2D) estimating methods, even when comprehensive estimates were provided by relatively unskilled estimators, notably with a decrease in errors and time required.

Challenges of 5D BIM in Construction Management

It was discovered that estimating with 3D software was superior to conventional 2D estimating and produced fewer errors and shorter estimation times. However, companies are hesitant to use 5D BIM since it does not work with the standard elemental format for cost planning. BIM models now have a lot of design flaws and frequently have crucial information missing from them, making it difficult to use BIM to generate 5D cost services since the data is either too inaccurate or incomplete (Boon & Prigg, 2012).

Besides, a lack of integration in BIM models also diminishes the dependability and efficiency of 5D. It is important to strike a balance between the information, and the deployment of 5D BIM is said to be hindered by this fundamental problem, or lack of integration, where parties in the industry are stated to work separately. As a result, this also divides the information needed for BIM (Althea & Balakumar, 2018).

Upgrades to software and hardware are regarded as major barriers to BIM deployment as well, especially for small-to-medium-sized businesses. BIM deployment comes with a stringent training requirement that, despite being time-consuming and challenging, is seen as essential to its adoption (Md.Rafi & Brahma Chari, 2019).

In addition, some businesses believe their current software satisfies their requirements; thus, they see no reason to make changes. Smaller businesses believe that 5D is not now a practical alternative. This trait

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

of smaller consulting firms is demonstrated by a study of Small- and Medium-Sized Enterprises (SMEs), which discovered that 73% of respondents believe that BIM implementation presents significant financial and commercial challenges and that 76% of small businesses lack BIM experience and thus have limited knowledge of the more intricate details (Samphaongoen, 2010).

RESEARCH METHODOLOGY

The data can be gathered in a variety of ways and from a variety of sources. Data collection for this study utilises a quantitative technique using an online survey with a questionnaire that has been sent through platforms such as email, WhatsApp, Telegram, and others. The respondents for this survey are among the contractors, consultants, and developers in the Malaysian Construction Industry. The survey was disseminated to targeted respondents situated within the Klang Valley region. By focusing on this geographical area, this study aimed to gather insights from a representative sample of professionals actively engaged in Malaysia's construction sector. The choice of Klang Valley as the survey location was strategic, given its concentration of construction activities and the presence of key industry players, which would provide relevant and valuable data for the study.

The survey form used contains a closed-ended type of questionnaire. The following are the questionnaire structures:

Part A: Respondents' Demographic Background

Part B: The development of 5D BIM in Construction Management

Part C: The implementation of 5D BIM in Construction Management

Part D: The Challenges of 5D BIM in Construction Management

Part E: The Solution of 5D BIM in Construction Management

The literature review has been conducted as an explanation for secondary data before the survey. A variety of sources, including books, journals, articles, and any relevant online sources, were required to complete and structure the literature review and to get input for the questionnaire in the survey. Survey results were then descriptively analysed using SPSS employing frequency analysis and Average Index (AI) based on a Likert scale rating of Strongly Disagree to Strongly Agree (1-5) (Table 1). The findings were summed up and demonstrated as tables and charts. In this paper, the findings highlighted focus more on the perceived benefits and challenges respondents faced about using 5D BIM in construction management.

Table 1. Average Index Classification

Description / Classification	Average Index (AI)
Strongly Disagree	$0.00 > AI \leq 1.50$
Disagree	$1.50 > AI \leq 2.50$
Neutral	$2.50 > AI \leq 3.50$
Agree	$3.50 > AI \leq 4.50$
Strongly Agree	$4.50 > AI \leq 5.00$

Source: Sandirasegaran & Manap (2016); Adapted from Likert (1932)

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

RESULT AND DISCUSSION

Respondents' Background Information

A total of one hundred 166 respondents were obtained from the survey conducted for this study. The respondents are between the ages of 26 and 30, while there is also a sizable presence from the 31 to 40 and 41 to 45 age groups. Their combined experience in the construction sector ranges from 7 to 10 years to 16 to 20 years. The majority of respondents are independent contractors who mostly handle projects and coordinate designs. The great majority utilise BIM, and many of them have three to five years of expertise. The distribution of responses is described below in Table 2.

Table 2. Respondents' Background Information

Questions	Response Options	Percentage (%)
Your age?	20 - 25 years old	10.2%
	26 - 30 years old	48.8%
	31 - 40 years old	22.9%
	41 - 45 years old	18.1%
	> 45 years old	0%
Your years of experience in the Construction Industry?	1 - 3 years	9%
	4 - 6 years	3.7%
	7 - 10 years	33.1%
	11 - 15 years	21.1%
	16 - 20 years	33.1%
	> 20 years	-
Your company/organisation?	Consultant	5.4%
	Contractor	77.7%
	Developer	16.9%
Your role in the construction management team?	Project Manager	39.8%
	Design Coordinator	36.7%
	Site Engineer	2.4%
	Quantity Surveyor	20.5%
	Assistant Architect	0.6%
Are you a BIM user?	Yes	95.2%
	No	4.8%
Years of using BIM?	None	3.6%
	1 - 2 years	7.8%
	3 - 5 years	49.4%
	6 - 10 years	21.1%

Source: Authors (2024)

According to the respondents' demographic information, 48.8% of them are between the ages of 26 and 30. The next age groups are as follows: 22.9% are between the ages of 31 and 40, 18.1% are between the ages of 41 and 45, and 10.2% are between the ages of 20 and 25. There are no responders older than 45.

33.1% of respondents reported having between 16 and 20 years of experience in the construction business, while an equal proportion (33.1%) reported having between 7 and 10 years of experience. 3.7% have four to six years of experience, 9% have one to three years, and 21.1% have between eleven and fifteen years. More than 20 years of experience was not mentioned in any reply. When it comes to the kind of business or organisation, 77.7% of respondents said they are employed by contractors. 5.4% of consultants and 16.9% of developers are the next in line.

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

Project Managers make up 39.8% of the respondents, followed by Design Coordinators (36.7%), Quantity Surveyors (20.5%), Site Engineers (2.4%), and Assistant Architects (0.6%) in the construction management team. 95.2% of respondents use BIM (Building Information Modelling), compared to 4.8% who do not. Of those who use BIM, 49.4% have done so for three to five years, 21.1% for six to ten years, 7.8% for one to two years, and 3.6% have not used BIM at all.

What are the most significant benefits of using 5D BIM in construction management?

There are five options listed in the questionnaire survey to rate by the respondents including optimised time management, improved quality control, improved cost estimation, more efficient scheduling, and no idea about the benefits is also included in the options. Fig. 1 below describes the responses by the respondents by percentage.

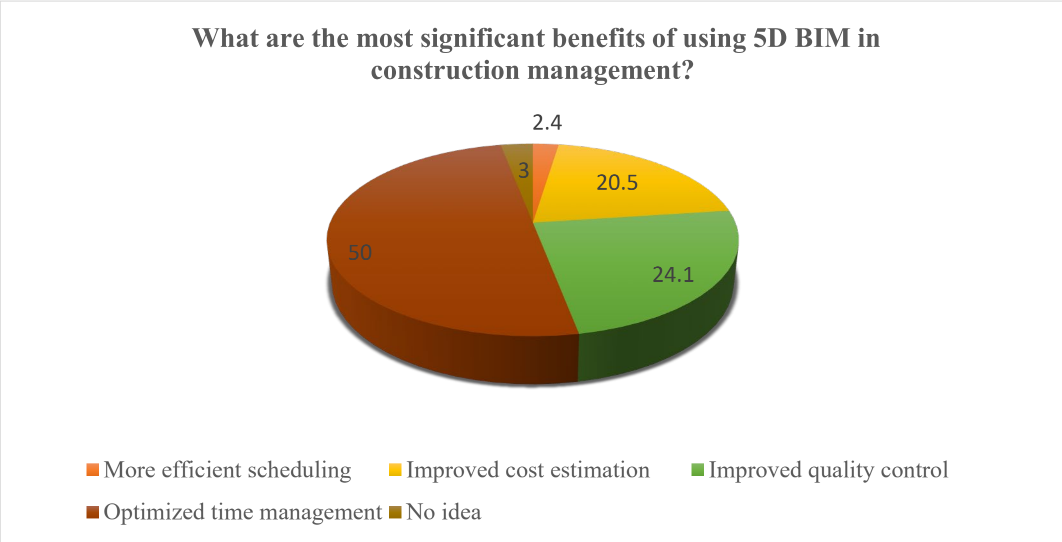

Fig. 1. The Most Significant Benefits of Using 5D BIM in Construction Management

Source: Authors (2024)

When the benefits of 5D BIM are examined, the respondents' opinions vary. The lowest group, 2.4%, links it to more effective scheduling, while 20.5% perceive it as improving cost estimation. 24.1%, or another significant majority, believe it improves quality control. Remarkably, half of the respondents (50%) credit 5D BIM for improved time efficiency. Conversely, 3% indicate that they do not fully comprehend 5D BIM advantages, suggesting possible gaps in knowledge. Altogether, there are different opinions about the benefits of 5D BIM in building projects, as this brief study shows.

This study suggests that respondents are aware of how adding 5D BIM may improve the precision and effectiveness of cost-estimating procedures in building projects. Their remarks emphasise how 5D BIM is thought to be valuable in helping to make more accurate and consistent cost projections, which might improve financial management and budgeting for building projects. In line with the statistics, research published by the Royal Institute of Chartered Surveyors (RICS) states that 5D BIM is acknowledged for its capacity to produce cost estimates that are more precise and dependable (Smith, 2016). The most frequently reported BIM benefit was the increased accuracy in cost estimates, which led to more effective cost reduction and control throughout the project lifecycle (Bryde et al., 2013). By providing detailed and

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

reliable cost projections early on, the project was better equipped to manage budgets, avoid cost overruns, and ensure financial efficiency from start to finish.

In terms of improving quality control, 5D BIM is instrumental in preventing costly construction errors by identifying potential clashes between elements early on. This early detection ensures higher quality standards by reducing time delays, cutting costs, and minimizing discrepancies throughout the project. Any updates to the BIM model are instantly recognised by all stakeholders, hence enhancing quality control (Katke, 2020). Moreover, cost considerations mainly relate to the 5D aspect, where 3D elements are connected to material costs. This allows BIM users to create accurate cost estimates by automatically extracting quantities from the model. It will then improve quality control by providing quick cost feedback during design changes and helping to understand the financial impact of design decisions (Ismael & Isik, 2017).

The most commonly reported benefit of using BIM was cost reduction and control throughout the project lifecycle, along with notable time savings (Bryde et al., 2013). This is in line with the conclusion that 50% of respondents think it helps in this area. Arif and Ayesha (2019) concluded that, despite some challenges and barriers to 5D BIM implementation, BIM and 5D construction processes are valuable tools for construction planning. 5D BIM modelling significantly enhances time efficiency by streamlining project timelines and reducing costs. It achieves this through improved visualisation of construction activities, enhanced communication among project teams, and the creation of detailed, accurate work plans and quantity takeoffs. Additionally, as the complexity of a project increases, such as with multi-story buildings, the time and cost-saving benefits of 5D BIM become even more pronounced.

A study by Lu et al. (2015) shows that although scheduling was not BIM's original main goal, its integration with 5D BIM has been proven to improve project scheduling efficiency to some extent. Meanwhile, research by Bråthen & Moum (2016) reveals that industry professionals continue to encounter significant knowledge gaps and challenges in fully understanding and utilizing BIM technology. This is aligned with the survey results highlighted that 3% of survey respondents were unable to identify any perceived benefits of using 5D BIM, indicating a lack of awareness or understanding of its advantages. Overall, the review of the extra comments shows a range of opinions, from optimism on the advantages of 5D BIM to acknowledging difficulties and respondent preferences. These observations can direct future deliberations and planning for the effective integration of 5D BIM into construction management.

What are the challenges of implementing 5D BIM in construction management?

Likert scale rating of Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree was employed to evaluate the challenges including the cost of implementing and maintaining 5D BIM technologies, technical limitations, difficulties in integrating 5D BIM with existing project workflows, integration and data management, lack of training and expertise in 5D BIM and lack acceptance and standardisation of 5D BIM practice. Fig. 2 and Table 2 below demonstrate the responses by the respondents by percentage.

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

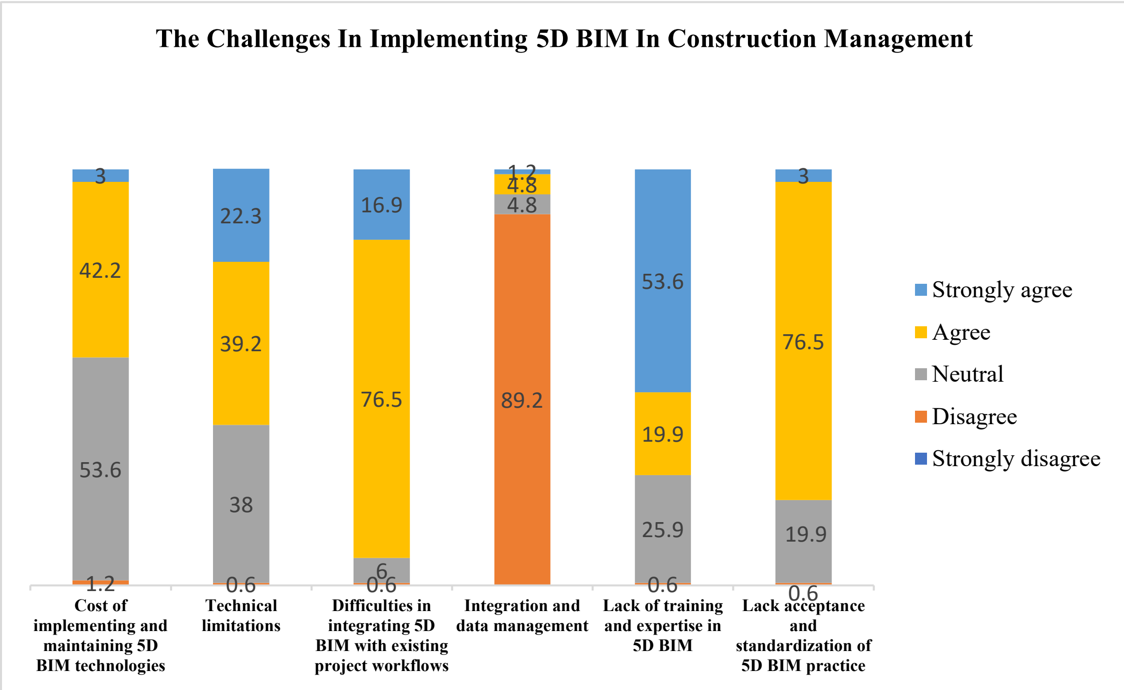

Fig. 2. Challenges in Implementing 5D BIM In Construction Management

Source: Authors (2024)

Table 3. The challenges in implementing 5D BIM in construction management

Item	Challenges	Weightage					Average Index (AI) = Mean Score	Rating
		1	2	3	4	5		
1	Cost of implementing and maintaining 5D BIM technologies	0	2	89	70	5	3.47	Agree
2	Technical limitations	0	1	63	65	37	3.83	Agree
3	Difficulties in integrating 5D BIM with existing project workflows	0	1	10	127	28	4.10	Agree
4	Integration and data management	0	148	8	8	2	2.18	Disagree
5	Lack of training and expertise in 5D BIM	0	1	43	33	89	4.27	Agree
6	Lack of acceptance and standardisation of 5D BIM practice	0	1	33	127	5	3.82	Agree

Source: Authors (2024)

Despite the highest average rating of 4.27, the biggest obstacle to deploying 5D BIM in construction management is a lack of training and experience. This suggests that a large number of industry experts lack the abilities and know-how required to use 5D BIM technology efficiently. With an average value of 4.10, the second main obstacle is the difficulty of integrating 5D BIM with current project operations. This implies that integrating 5D BIM into current procedures faces major obstacles, which might interfere with project schedules and workflows. The average rating of 3.83 for technical restrictions makes the adoption

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

of 5D BIM even more difficult because it might prevent the technology from being fully utilised. Furthermore, the industry's contrast and the lack of consistent rules or procedures are highlighted by the low score of 3.82 for the acceptance and standardisation of 5D BIM practice. A further significant barrier is the average cost of 3.47 for developing and maintaining 5D BIM technology, which may discourage businesses from utilizing them. With an average value of 2.18, integration and data management rank last but are nevertheless challenging, pointing to problems with data compatibility and efficient information administration.

This study implies an understanding of the existing difficulties or impediments to the widespread adoption of 5D BIM. The remarks emphasise how crucial it is for professionals to increase their knowledge and proficiency in 5D BIM to get over current obstacles and encourage more extensive and efficient use of this technology on a worldwide basis. Respondents preferred the traditional techniques of construction management over the usage of 5D BIM, suggesting that they found the conventional procedures to be easier. These remarks demonstrate the variety of attitudes and preferences seen in the construction business by shedding light on a subgroup of respondents' possible opposition or desire for tried-and-true procedures. A study by Olawumi & Chan (2018) addresses the obstacles to BIM adoption and points out that some professionals prefer the familiarity and apparent ease of use of older approaches. The report makes clear that one prevalent obstacle in the construction sector is reluctance to change. Similarly, several challenges hinder the implementation of 5D BIM within the construction industry as outlined by Hasan and Rasheed (2019) including cultural resistance, the belief among some companies that their existing software is more accurate than 5D BIM, the absence of standardised protocols for coding objects within building information models, and a shortage of qualified personnel to adopt and utilise this technology.

CONCLUSION

With the survey results and analysed findings, the study assesses the industry participants' perceived benefits and the difficulties involved in utilizing 5D BIM in construction management in the Malaysian Construction Industry. The survey indicates that the most significant benefit of using 5D BIM is optimised time management, followed by improved quality control and cost estimation. This aligns with existing literature, suggesting that 5D BIM enhances project scheduling efficiency and provides more accurate cost estimates. The primary challenges include a lack of training and expertise, difficulties in integrating 5D BIM with existing project workflows, technical limitations, and the cost of implementation and maintenance. These challenges reflect a need for enhanced training programs and better integration strategies. The development of comprehensive training programs is needed to improve the skills and expertise of construction professionals in using 5D BIM technology. Robust strategies must be created for integrating 5D BIM with existing project workflows. This includes developing standardised processes and protocols to ensure seamless integration and minimise disruptions. By implementing these recommendations, the construction industry in Malaysia can better leverage the potential of 5D BIM in construction management, leading to improved project outcomes, enhanced efficiency, and greater overall productivity.

ACKNOWLEDGEMENTS/FUNDING

We would like to acknowledge the support of Universiti Teknologi MARA (UiTM) Shah Alam, Selangor, Malaysia and the College of Built Environment, UiTM Shah Alam for providing the facilities and support for this research.

CONFLICT OF INTEREST STATEMENT

I agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

AUTHORS' CONTRIBUTIONS

Author 1 conceptualized the study, designed the methodology, contributed to data collection and data analysis and interpretation, and drafted and revised the manuscript. Author 2 assisted with data collection and data analysis, contributed to the literature review, and participated in drafting the manuscript, and provided critical feedback during revisions. Each author has made substantial contributions to the work, ensuring the integrity and quality of the research presented.

REFERENCES

Althea, J., & Balakumar, P. (2018). 5D-Bim : Methodology, Advantages and Obstacles for Practical Implementation Along With Improvement Measures – a Review. *Journal of Emerging Technologies and Innovative Research (JETIR), 5*(9), 236–241. http://www.jetir.org/papers/JETIRA006302.pdf

Arif K., & Ayesha M. (2019). Creation of Formula to Predict Time and Cost Benefit by Using 5D BIM Rather than Traditional Method of Construction. *Advancements in Civil Engineering & Technology*, *3*(1), 270-277. https://doi.org/10.31031/acet.2019.03.000552

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and management in engineering*, *11*(3), 241-252. https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

Boon, J., & Prigg, C. (2012, February). Evolution of quantity surveying practice in the use of BIM–the New Zealand experience. In *Proceedings of the CIB International Conference on Management and Innovation for a Sustainable Built Environment* (pp. 84-98). https://www.irbnet.de/daten/iconda/CIB_DC25601.pdf

Bråthen, K., & Moum, A. (2016). Bridging the gap: bringing BIM to construction workers. *Engineering, construction and architectural management*, *23*(6), 751-764. https://doi.org/10.1108/ECAM-01-2016-0008

Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of building information modelling (BIM). *International journal of project management*, *31*(7), 971-980. https://doi.org/10.1016/j.ijproman.2012.12.001

Gohil, P. P., Malek, M., Bachwani, D., Patel, D., Upadhyaya, D., & Hathiwala, A. (2022). Application of 5D Building Information Modeling for Construction Management. *ECS Transactions*, *107*(1), 2637. http://doi.org/10.1149/10701.2637ecst

Hasan, A. N., & Rasheed, S. M. (2019). The benefits of and challenges to implement 5D BIM in construction industry. *Civil Engineering Journal*, *5*(2), 412. https://doi.org/10.28991/cej-2019-03091255

Hathiwala, A. M., & Pitroda, J. R. (2021). Application of 5d building information modeling for construction management. *Solid State Technology*, *64*(2), 2156-2163. https://solidstatetechnology.us/index.php/JSST/article/view/9564

Ismael, S. F., & Isik, Z. (2017). 5D BIM Based Construction Quality Lifecycle Inspection Model. *Tamap Journal of Engineering*, *12*(1), 37-42. https://www.tamap.org.tr/public/files/document/5d-bim-based-construction-quality-lifecycle-inspection-model.pdf

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418

Katke, S. S. (2020). Time and Cost Control of Construction Project using 5D BIM process. *International Research Journal of Engineering and Technology (IRJET)*, *7*(8), 3247–3257. https://www.irjet.net/archives/V7/i8/IRJET-V7I8547.pdf

Kong, S. W. R., Lau, L. T., Wong, S. Y., & Phan, D. T. (2020). A study on effectiveness of Building Information Modelling (BIM) on the Malaysian construction industry. In *IOP Conference Series: Materials Science and Engineering* (Vol. 713, No. 1, p. 012035). IOP Publishing. https://doi.org/10.1088/1757-899X/713/1/012035

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology, 22 140,* 55. https://legacy.voteview.com/pdf/Likert_1932.pdf

Lu, W., Fung, A., Peng, Y., Liang, C., & Rowlinson, S. (2015). Demystifying construction project time–effort distribution curves: BIM and non-BIM comparison. *Journal of management in engineering*, *31*(6), 04015010. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000356

Md Rafi, P., & Brahma Chari, K. J. (2019). 5D Application of BIM in Construction Management. *International Journal of Recent Technology and Engineering (IJRTE)*, *7*(6C2 April 2019), 97–101. https://www.ijrte.org/wp-content/uploads/papers/v7i6c2/F10180476C219.pdf

Mustafa, M. H., Rahim, F. A. M., & Chia, L. K. (2023). The role of 5D building information modelling in construction project cost management: An overview and future directions. *Journal Of Project Management Practice (JPMP)*, *3*(1), 95-112. https://doi.org/10.22452/jpmp.vol3no1.5

Nast, A., & Koch, C. (2023). Practical experiences with 5D building information modeling–A systematic literature review. *ECPPM 2022-eWork and eBusiness in Architecture, Engineering and Construction 2022*, 508-515. https://doi.org/10.1201/9781003354222-65

Noviani, S. A., Amin, M., & Hardjomuldjadi, S. H. (2022). The impact of 3D, 4D, and 5D Building Information Modeling for reducing claims to service providers. *SINERGI*, *26*(1), 47-56. http://doi.org/10.22441/sinergi.2022.1.007

Olawumi, T. O., & Chan, D. W. (2018). Identifying and prioritizing the benefits of integrating BIM and sustainability practices in construction projects: A Delphi survey of international experts. *Sustainable Cities and Society*, *40*, 16-27. https://doi.org/10.1016/j.scs.2018.03.033

Samphaongoen, P. (2010). *A visual approach to construction cost estimating*. Marquette University. https://epublications.marquette.edu/cgi/viewcontent.cgi?article=1027&context=theses_open

Sandirasegaran, K., & Manap, N. (2016). Impacts of dredging and reclamation projects. *Jurnal Teknologi*, *78*(3), 139-143. https://doi.org/10.11113/jt.v78.9506

Smith, P. (2016). Project cost management with 5D BIM. *Procedia-Social and Behavioral Sciences*, *226*, 193-200. https://doi.org/10.1016/j.sbspro.2016.06.179

https://doi.org/ 10.24191/bej.v21iSpecial Issue.2418