SEMARAK ILMU PUBLISHING
202103268166(003316878-P)

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943


# A Systematic Literature Review: Implementing Building Information Modelling (BIM) for TVET Educators in Malaysia

Nurul Hazalia Ismail[1,2,*], Ernawati Mustafa Kamal[1], Muhammad Fahmi Mohd Fizal[3]

[1] School of Housing, Building, and Planning, Universiti Sains Malaysia, 11800 Gelugor, Pulau Pinang, Malaysia
[2] Civil Engineering Department, Politeknik Sultan Abdul Halim Mu'adzam Shah, Bandar Darulaman, 06000 Jitra, Kedah, Malaysia
[3] BIM Modeller, China Harbour (Singapore) Engineering Company Pte Ltd, 300 Beach Road, 199555 Singapore

**ARTICLE INFO**

***Article history:***
Received 28 November 2023
Received in revised form 29 April 2024
Accepted 15 June 2024
Available online 25 July 2024

***Keywords:***

Educators; BIM barriers; Malaysia TVET institutions; systematic literature review

**ABSTRACT**

Building Information Modelling (BIM) education hinges on cooperation with the industry, universities, technical colleges, and communities by allowing practice and specialisation in training. This requires studying specific issues in implementing BIM for TVET educators in Malaysia to unveil the current status of BIM in the profession. The Malaysian TVET Institutions are responding to these barriers by implementing BIM with a curriculum design. The collaboration extends to multiple professionals in the industries, mainly by providing adequate education and training to their educators. With this objective, a systematic literature search of the Web of Science (WoS) and SCOPUS databases was carried out using the Reporting Standards for the Systematic Evidence Synthesis (ROSES) method. Based on keywords, abstracts, and full article content, inclusion and exclusion criteria were chosen to thoroughly study 14 articles, analyse their integration and evaluation methods, and derive findings. The findings serve as empirical evidence to determine the barriers to implementing BIM among educators in Malaysia TVET institutions. The barriers such as change management, transitioning from traditional educational paradigms, faculty expertise gaps, misalignment with industry needs, and limited exposure to real-world working environments need to be addressed. The paper concluded by recommending strategies for implementing BIM among educators. The outlined strategies can help in the decision-making process for BIM implementation in Malaysian TVET Institutions, thus helping educators mitigate barriers and prepare effective strategies for BIM implementation.

## 1. Introduction

TVET, which stands for technical and vocational education and training, aims to equip students with the skills and knowledge necessary to become skilled professionals [1]. The TVET programme is critical in generating the skilled workforce needed for economic growth in Malaysia [1-5]. However, challenges are emerging, such as rapid technological change, evolving industry demands, and the need for educators and students to be digitally literate. These challenges highlight the need for new

* *Corresponding author.*
*E-mail address: hazalia@student.usm.my*

https://doi.org/10.37934/araset.49.1.194210

TVET programmes using Building Information Modelling (BIM) and emphasise the application of advanced tools. Malaysia has adopted several strategies and initiatives to implement TVET reforms through TVET institutions. These efforts include the implementation of industry-led curricula, teaching staff development, and high-tech and value-added programmes being developed. Additionally, many departments and professionals work together and provide excellent education and training to their students [4,6].

Furthermore, BIM, or Building Information Modelling, is "a modelling technology and process for creating, communicating, analysing and applying digital information models during the life cycle of a construction project [7]. Predominantly, BIM is widely used in the design phase [8] of the construction industry with the increasing complexity of the construction industry and advances in computer technology. BIM has been integrated into the Architecture, Engineering, and Construction (AEC) management team [8]. BIM drives the direction of training and adoption, especially from an organisational perspective. A specific research direction investigates effective BIM training strategies for small firms that frequently encounter resource constraints in the construction industry [9,10]. This finding is important, as larger companies generally have more resources to train their employees. If BIM training is understood in smaller companies, it will give you a snapshot of BIM acceptance across the industry, which goes deeper.

This approach will help ensure effective BIM performance across the wider industry, increasing overall productivity and collaboration in the construction industry. There may be an organisation for the first phase of introductory activities. During the first introductory implementation phase, the institution can develop learning objectives and curriculum and develop courses/designs that integrate BIM into the curriculum. A process-based learning approach in business education is a general introduction to the methodological understanding of BIM [11,12].

In addition, a recent study by [13] suggested that the Malaysian government has implemented BIM in education. Participants receive professional certification. The integration of BIM into Malaysian TVET is an essential step towards upgrading technology and bringing it in line with global construction standards. The adoption of BIM can provide Malaysian TVET students with a competitive edge in the international industry [4,6]. Additionally, it prepares them for a construction industry that relies heavily on digital technologies, enhancing their productivity and skills. The role of teachers is crucial in this transformation. To use BIM successfully, educators must have technical knowledge of BIM software and an understanding of its implications for project management and collaboration [14]. Professional development programmes and partnerships with industry specialists can play a vital role in preparing teachers for this change.

In short, the use of BIM in educational systems is still being piloted with new technologies, which gave TVET a better understanding of BIM application capabilities [12]. Integrating BIM into the Malaysian TVET programme aligns it with global industry standards and equips future workers with appropriate skills. In particular, this requires concerted efforts from various stakeholders, including academics, industry partners, and policymakers. Therefore, this study aimed to conduct a Systematic Literature Review (SLR) that proposed strategies for the implementation of BIM for TVET educators in Malaysia—the application of empirical evidence to identify gaps and guide future research. Thus, this study can assist TVET educators in Malaysia in the decision-making process for implementing BIM, thus helping educators to reduce barriers and prepare best practices for implementing BIM in institutions.

### *1.1 The Importance of a Systematic Literature Review*

SLR is a framework that integrates scientific evidence and answers specific research questions. It also serves as an explicit tool for gathering all published evidence, criticising any research, and asking factual questions to seek evidence and information gathered high edge [15]. The SLR is meticulously designed to determine and evaluate the quality of the study and optimise it for evaluation [16]. It has great potential for design research, addressing critical issues. However, there is an urgent need to define appropriate review methods for research questions in systems research and to tailor guidelines to specific needs and characteristics.

Despite the global spread of many SLRs related to the use of BIM, only a few focuses specifically on BIM in education and TVET institutions. Sinoh [17] requested a comprehensive nationwide systematic study on BIM in Malaysia to better understand the current state of BIM in the country. This understanding is essential in order to develop appropriate strategies to maximise the implementation of BIM [18]. It is imperative to identify the barriers in educational institutions and propose recommendations to address them in the education system [19]. A study by Puolitaival and Forsyth [20] identified a number of barriers to BIM education, such as a lack of teaching and learning materials, difficulties with preventative theory and practice, gaps between traditional and modern construction project management between methods, and a focus on educators in the existing literature. Recently, Waqar [21] discovered ten primary categories: complexity, cost, culture, digital adoption, expertise, interest, legislation, safety, safety management resources, and technology, as displayed in Figure 1. Implementing BIM in the education system is still piloted with these new technologies [8]. Thus, the scenario has led to several understandings of educators in the TVET's ability to implement BIM in education, address the barriers, and prepare strategies to mitigate the obstacles.

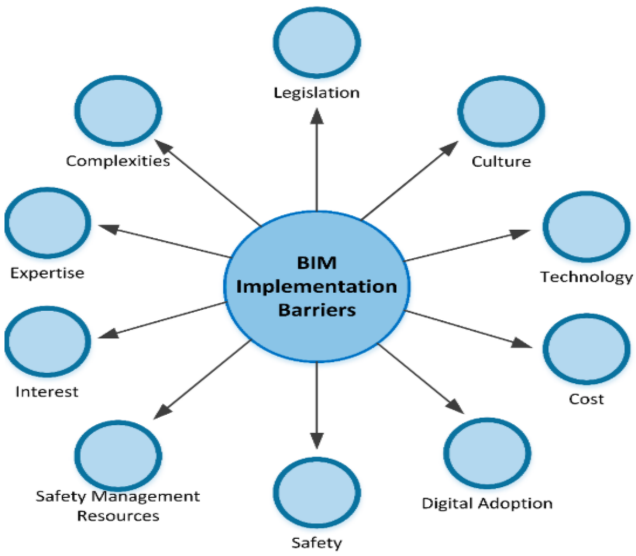


**Fig. 1.** Barriers to Implementing BIM [21]

Zhang [22] emphasised this point, pointing out global concerns over the lack of BIM education in university education, especially as the demand for BIM skills continues to increase through the implementation of BIM in education systems that are still being researched with new technologies. Recognising this gap in the literature, the present study focuses on the implementation of SLR targeting strategies for implementing BIM specifically for TVET educators in Malaysia. This paper is organised into five separate sections to provide an overview of the study:

i. Introduction
ii. Methodology
iii. Results and Discussion
iv. Conclusion
v. Acknowledgement

Empirical evidence was carefully reviewed to distinguish and justify this approach, thus guiding future research. The study proceeds with the intention of answering two main research questions.

i. What are the barriers for scholars to implement BIM in Malaysian TVET institutions?
ii. What are the recommended strategies for implementing BIM among TVET educators?

## 2. Methodology

The five subsections of the methodology were provided within this section:

i. Method of Review
ii. Determining the Research Objectives
iii. Systematic Searching Strategies
iv. Methodological Quality Assessment
v. Systematic Review and Data Analysis.

### *2.1 Method of Review –Reporting Standards for the Systematic Evidence Synthesis (ROSES)*

The Reporting Standards for the Systematic Evidence Synthesis (ROSES) method was employed as a guide for these SLRs since this method is suitable for systematic reviews and mapping [23]. This approach was used to ensure that the researchers would provide accurate and comprehensive data. Carefully develop appropriate search objectives, formulate a structured search strategy that includes identifying, testing, and identifying eligibility criteria, presenting the quality of selected information, and describing data extraction.

### *2.2 Determining the Research Objective*

The research questions of the study were developed using the PICo system, which helps researchers prepare appropriate research questions for review. The PICo is based on three main considerations: population or problem, interest, and context. Identifying the barriers and proposing strategies for TVET educators in Malaysia BIM implementation is the main research objective of the study, based on three main areas of research: Malaysian TVET educators (demographics), BIM implementation (interest), and methods (context).

### *2.3 Systematic Searching Strategies*

A search strategy was designed to serve three main purposes:

i. Identification

ii. Screening
iii. Eligibility determination.

### *2.3.1 Identification*

The SLR process consisted of three steps. The first step identified synonyms, related terms, and keyword modifications (“building information modelling,” “implementation,” and “educator”) through an online thesaurus and past studies. The second step used SCOPUS and Web of Science (WoS) to develop a search string. Search strings were constructed based on search, truncation, wild-card, and field-code operations. The final step involved screening articles for inclusion in the review. The SCOPUS and WoS databases are primary databases for SLRs due to their advanced literature search capabilities, comprehensive quality control, and multidisciplinary focus [23]. Search strings (Table 1) were developed in March 2023 after determining relevant background keywords.

**Table 1**
The search string

| Database | Search String |
|---|---|
| Scopus | TITLE-ABS-KEY ((“building information model*” OR “BIM”) AND (“awareness” OR “consciousness” OR “perception” OR “understand*” OR “knowledge” OR “alertness” OR “recognition”) AND (“educator*” OR “higher education” OR “education system” OR” education* institution” OR “TVET institution”)) |
| Web of Science | TS= ((“building information model*” OR “BIM”) AND (“awareness” OR “consciousness” OR “perception” OR “understand*” OR “knowledge” OR “alertness” OR “recognition”) AND (“educator*” OR “higher education” OR “education system” OR” education* institution” OR “TVET institution”)) |

### *2.3.2 Screening*

During the SLR, 197 articles were initially selected using predefined criteria, and the ranking function of the database-specific criteria will be established for inclusion or exclusion [24]. Since it is impractical to review all cases, Krause [25] recommended focusing on a specific time period. As a result, the search focused on articles published in English with interventions from 2018 to 2023 to ensure relevance and quality. This procedure excluded 146 articles that did not meet these criteria or were duplicates, reducing the selection to 51 articles for the final eligibility analysis.

**Table 2**
Inclusion and exclusion criteria

| Criteria | Inclusion | Exclusion |
|---|---|---|
| Timeline | 2018 - 2023 | 2017 and earlier than 2017 |
| Document Type | Article (empirical data/not focused on BIM) | Review article, chapter in a book, book, conference proceeding, etc |
| Language | English | Non-English |

### *2.3.3 Eligibility determination*

In the third stage of eligibility, a total of 51 articles were examined extensively. At this stage, abstracts and main articles were thoroughly examined to ensure they met the inclusion criteria and were relevant to the current research objectives. This comprehensive review excluded 34 articles; in particular, findings that are not available or directly relevant to the focus of this study will not be accepted. Accordingly, this process resulted in the remaining 14 articles deemed worthy of in-depth analysis, as illustrated in Figure 2.

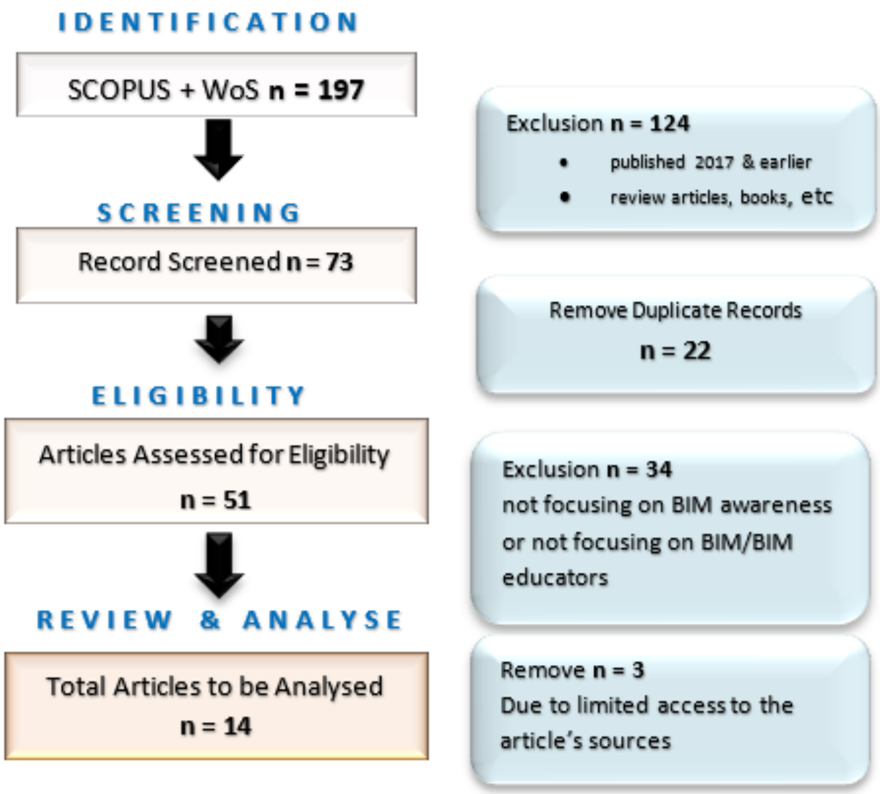


**Fig. 2.** Flow diagram of the search process

*2.4 Assessing the Methodological Quality of the Studies*

The methodology and analysis of the selected studies were assessed to ensure their completion was satisfactory [24]. Primary Studies (PSs), original research articles that address a specific research question, were selected for this purpose. Assessing the quality of PSs is an essential step in an SLR to determine the credibility and validity of the evidence presented in the studies by two experts. The articles were rated using the Quality Assessment (QA) criteria based on the guidelines proposed by [26], which included clarity of the study's purpose, value of the work, establishment of methodology, definition of concepts, comparison with similar work, and mention of limitations. The QA was evaluated using a scoring procedure where YES (Y) = 1, PARTLY (P) = 0.5, and NO (N) = 0. The researcher generally confirmed that the chosen articles met the minimum quality standard of 3.0. Kitchenham [26] stated that the number of articles for SLR is usually fewer than 50 or often fewer than 10. Thus, the 14 articles selected for the SLR fulfilled all the criteria with a score of more than 3.

*2.5 Data Extraction and Analyses*

The review technique included different research designs (quantitative, qualitative, mixed methods) in the review. According to Whittemore and Knafl [27], qualitative or mixed methods are the most effective approach to analysing integrative data, allowing researchers to interact with primary data sources. In this study, a qualitative approach was chosen. The researcher thoroughly read 14 articles, particularly their abstracts, results, and discussion sections. Data extraction was conducted based on research questions. Any relevant data that could answer the research questions were abstracted and placed in a table.

Thematic analysis was conducted to identify patterns, clusters, counts, similarities, and relationships [28]. According to Flemming [29], when dealing with a mixed research design, thematic analysis is the most suitable method for synthesising the data design. This flexible data reduction method can be combined with other data analysis techniques [30]. The first data extraction step followed a qualitative approach with NVivo Plus version 14 software as a tool. The research questions guided the data mining process, as contents were probed for comparative content analysis and coded for emerging themes and patterns. Patterns among the abstracted data about two principal codes and four sub-codes were created and examined. The themes derived were reviewed to ensure accuracy and usefulness in representing the data.

## 3. Results and Discussion

NVivo Plus version 14 software was analysed for the 14 articles. The results are presented in two (2) themes illustrated in Table 3 (Themes and Subthemes):

i. Barriers to implementing BIM in education
ii. Strategies for Implementing BIM to TVET Educators in Malaysia with four subthemes (curriculum integration, university-industry collaboration, education, and training and new technology adoption).

**Table 3**
Themes and subthemes

| Author(s) | The barriers to implementing BIM in education | Strategies for implementing BIM in educational institutions | | | |
|---|---|---|---|---|---|
| | | Curriculum integration | HEIs-industry collaboration | Education and training | New technology adoption |
| Agirbas | | | | √ (1) | |
| Alizadehsalehi *et al.,* | √ (1) | √ (1) | | | |
| Aziz *et al.,* | √ (1) | √ (1) | | √ (1) | √ (1) |
| Babatunde *et al.,* | √ (1) | | | √ (1) | |
| Casasayas *et al.,* | √ (7) | | √ (1) | | √ (1) |
| Chen *et al.,* | √ (4) | √ (1) | √ (1) | | |
| Commons & Ozcan Deniz | | √ (1) | | | √ (1) |
| Dan *et al.,* | | √ (1) | | | |
| Isanović & Çolakoğlu | √ (1) | | √ (1) | | |
| Ismail *et al.,* | √ (2) | √ (2) | | | |
| Lassen *et al.,* | √ (2) | √ (2) | | | |
| Maharika *et al.,* | √ (3) | √ (1) | √ (1) | √ (1) | √ (4) |
| Nikolic | √ (1) | | | | √ (1) |
| Zhang *et al.,* | √ (2) | | √ (1) | √ (1) | |

*Remarks: √ ( ) Number/s reading found in the article*

### *3.1 Barriers to implementing BIM in education*

Table 4 reveals the barriers to implementing BIM in education.

**Table 4**
Barriers to implementing BIM in education

| Author/s | Journal Title | Results and Discussion |
|---|---|---|
| [45] | Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution | Higher education institutions face significant barriers to managing multidisciplinary collaborations, particularly with departments such as architecture, planning, building surveying, engineering, and other fields related to the built environment. These collaborations, essential for fostering a comprehensive educational approach, required a harmonious integration of diverse disciplines, each with its unique perspectives and methodologies. The complexity of coordinating these varied fields posed a considerable hurdle for the institution, underscoring the need for effective communication and collaborative strategies to bridge the gaps between different educational areas. |
| [45] | Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution | Higher education institutions face significant barriers to managing multidisciplinary collaborations, particularly with departments such as architecture, planning, building surveying, engineering, and other fields related to the built environment. These collaborations, essential for fostering a comprehensive educational approach, required a harmonious integration of diverse disciplines, each with its unique perspectives and methodologies. The complexity of coordinating these varied fields posed a considerable hurdle for the institution, underscoring the need for effective communication and collaborative strategies to bridge the gaps between different educational areas. |
| [34] | Analysis of the drivers and benefits of BIM incorporation into quantity surveying profession Academia and students' perspectives. | The importance given to education and industry may overlap or differ significantly between these two sectors. This diversity highlights the specific priorities and objectives that are reflected in each category. While industry tends to focus on practical applications and immediate market needs, education can emphasise theoretical clarity and longer-term knowledge development. Understanding these differences is critical to achieving meaningful collaboration and developing courses to bridge the gap between educational learning and industry needs. |
| [36] | University-industry collaboration for BIM education: Lessons learned from a case study | Interactions between universities and industry play an important role in the dynamic environment of Building Information Modelling (BIM) education. Higher Institution Educators played a key role in helping industry representatives understand how their participation could further enhance students' knowledge of BIM and support their understanding of business issues, thus learning the main effects. However, this process is not without its barriers. Changing existing systems has been difficult, mainly due to inadequate educator qualifications and apparent mismatches between educational outcomes and industry needs. |
| [39] | Students' perceptions of BIM learning scenario in architectural education | In an age of rapidly advancing technology, many leading physicians find it difficult to stay abreast of the latest trends. This situation highlights the critical need for educated practitioners who are well-versed in current developments and can skilfully navigate the changing landscape. This gap between the speed of technological progress and the ability of firms to keep pace underscores the importance of continuous learning and adaptation in the industry. |

| | | |
|---|---|---|
| [40] | Enhancing The Graduates' Employability and Career Development Through Building Information Modelling Intensive Training | The knowledge about BIM management, communication, and operations is often limited. This limitation is compounded by the fact that many individuals have minimal existing knowledge of BIM and skills in using relevant software applications, but despite these limitations, ability there is an incredible potential for faster learning, especially when individuals are presented with real-world problems, which facilitates faster reactions and more effective learning processes. This situation highlights the potential for growth and skill development in BIM among those who initially had limited knowledge and skills in this area. |
| [41] | Enhancing learning outcomes by introducing BIM in civil engineering studies – experiences from a university college in Norway | Integrating BIM into the already intensive advanced engineering curriculum is a major hurdle for educators. Balancing the introduction of this complex and essential tool with the existing comprehensive course load is a challenge. However, the ability of students to adapt and learn quickly, especially when faced with tasks related to real-world problems, reveals potential solutions. |
| [46] | Building Information Modelling (BIM) Adoption Model for Architectural Education | The current focus on adopting BIM is primarily targeted at the construction industry, including consulting firms and contractors. However, this perspective ignores the barriers and some needs faced by educational institutions. These barriers include lack of IT infrastructure, demanding BIM, lack of clear government guidelines, costs associated with training of staff educators and qualified staff to teach BIM courses, the need for continuity development of new software, as well as standards and accreditation requirements to guide the use of BIM in educational courses. |
| [32] | Assessment of AEC Students' Performance Using BIM-into-VR | The existing shortage of professionals in the AEC industry who are trained in BIM and Virtual Reality (VR) continues to be a significant barrier to collaborative working practices in this field. This gap in skilled personnel not only hinders the effective implementation of these advanced technologies but also limits the potential for enhanced collaboration and efficiency that BIM and VR can bring to the industry. Addressing this shortage is crucial for unlocking the full potential of these technologies in transforming working practices within the AEC sector. |
| [43] | Teaching BIM as a collaborative information management process through a continuous improvement assessment lens: a case study | The implementation of BIM has been slow and inconsistent, mainly due to the greater need to increase the skills to use this technology effectively in projects. This need for advanced training and skills development represents a significant barrier, hindering the seamless integration and implementation of BIM across sectors. Overcoming this barrier is essential in order to fully realise the potential benefits of BIM across the industry. |
| [44] | Evaluation Framework for an Interdisciplinary BIM Capstone Course in Highway Engineering* | The industry has seen relatively little research devoted to improving BIM education, a gap that is all the more important given the current developments in BIM. This lack of collaborative efforts and knowledge sharing hinders the widespread understanding and application of leading BIM practices, which are crucial to keeping up with the evolving technological environment in the industry. |

### *3.2 Strategies for Implementing BIM in Educational Institutions*

By identifying the barriers to BIM implementation in education, the subsequent strategies for implementing BIM can be delineated in Table 5.

**Table 5**
Strategies for implementing BIM in TVET educational institutions

| Author/s | The proposed strategies for implementing BIM in TVET educational institutions | | | |
|---|---|---|---|---|
| | Curriculum integration | HEIs-industry collaboration | Education and training | New technology adoption |
| [32] | Learning multiple software applications is essential to overcome the interoperability issues that arise when converting from a 3D/BIM-based model to a VR-enabled model. | | | |
| [45] | In order to effectively implement BIM into the curriculum, it is important to adopt strategies such as facilitating conferences, facilitating collaboration, using an open learning approach, and learning a task-based implementation. | | BIM skills have been integrated into various parts of the education curriculum, but there is still room for more detailed and comprehensive training to fully utilise the technological potential of BIM in the industry. | Various learning methods, such as workshops, collaboration, open learning methods, and project-based learning, can be used to implement BIM effectively into the curriculum. |
| [34] | | | It is crucial for professionals to improve their skills and knowledge in BIM in order to use BIM effectively in their daily practices. This enhancement of expertise ensures that they can fully utilise the capabilities of BIM, thereby optimising their work processes and contributing to more efficient and innovative practices in their respective fields. | |
| [35] | | Collaboration between industry and government is essential for fostering advancements and effective implementations in various sectors. This partnership enables leveraging both public policy support and private sector innovation, leading to more efficient, sustainable, and beneficial outcomes for the broader community. | | Accreditation bodies and professional bodies should play a key role in knowledge transfer between industry and universities, acting as important mediators for bridging the gap between academic learning and practical industry applications. |

| | | | | |
|---|---|---|---|---|
| [36] | It may be beneficial to reorder the educational activities for the next iteration of Building Information Modelling (BIM) education. By doing so, the curriculum can be designed to build upon each concept in a progressive manner, thereby enhancing the learning experience. This approach will help students achieve a more comprehensive understanding of BIM, which is crucial for its effective application in practical scenarios. | The university identified the needs of the industry and the amount of practical knowledge required to implement BIM successfully. This accreditation is essential in a curriculum that not only covers theoretical aspects but also places greater emphasis on the practical application of BIM, ensuring that graduates are well-prepared to meet industry requirements. | | |
| [37] | The adoption of both CAD (Computer-Aided Design) and BIM in the AEC curriculum is essential, according to the results and directions presented in this study. | | | By gaining and enhancing their technical skills through the use of tools, students greatly improve their productivity. These skills are highly valued in the industry, and being proficient with these software applications directly benefits their career prospects. |
| [38] | Building Information Modelling (BIM) must be used effectively and thoughtfully to ensure that its integration into systems and processes is done in a way that maximises potential benefits. This deliberate approach is necessary to fully realise the efficiencies, accuracy, and collaboration improvements that BIM can bring to projects and industries. | | | |

| | | | |
|---|---|---|---|
| [39] | | Encouraging self-learning and learning style is important, as these are essential requirements for 21st-century curriculum. Such strategies allow students to manage their education, developing skills such as critical thinking and problem-solving that are invaluable in today's rapidly changing world. This focuses on personalises. | |
| [40] | Integrating BIM education into the curricula of Higher Education Institutions (HEIs) in Malaysia can be significantly enhanced by industry involvement in the training process. This collaboration helps establish a strong relationship between the industry and HE institutions, subsequently opening up opportunities for internship programs in BIM-based projects in the future. | Collaboration between professionals in the industry and the Higher Education Institutions (HEIs) sector is crucial. There needs to be a more vigorous effort in fostering collaboration between industrial practitioners and HE institutions. This active engagement is essential for helping academicians guide students effectively and for providing them with access to valuable BIM-based project information. | |
| [41] | BIM-based courses should be designed so that architecture is seamlessly integrated into these systems. At the same time, new ways of integrating BIM into the curriculum should be explored. This approach should aim to replace traditional engineering courses with innovative, reinforcing, balanced, and comprehensive educational experiences. | | |

| | | | | |
|---|---|---|---|---|
| [46] | The criteria of the curriculum must also involve the process of integration, ensuring that different elements and subjects are seamlessly blended. This integration is key to creating a comprehensive educational experience that holistically combines various disciplines and methodologies. | | Efforts should be made to develop and provide programmes aimed at strengthening skills in various skills. These policies are essential to ensure that individuals develop the abilities and skills necessary to be effective in their jobs, thus enhancing both professional development and productivity. | The transition to innovation in an academic environment requires collaboration between different sectors and professionals, emphasising the importance of a holistic approach. |
| [43] | | | | Managing the technical side of projects requires a broad understanding of resource availability, file storage capacity, and appropriate technology for a given project. This role is especially difficult when making decisions, as reflected in choosing software such as Solibri and Navisworks. |
| [44] | | | It is important to integrate opportunities for practical use, which are essential for a complete learning experience. Implementing BIM construction technology and BIM operation and maintenance processes. This approach not only enhances theoretical understanding but also ensures that students gain hands-on experience, which is crucial to successfully performing BIM applications in a real-world setting. | |

A detailed picture of the BIM barriers and proposed strategies for implementing BIM for TVET Educators in Malaysia discovered in this study is illustrated in Figure 3.

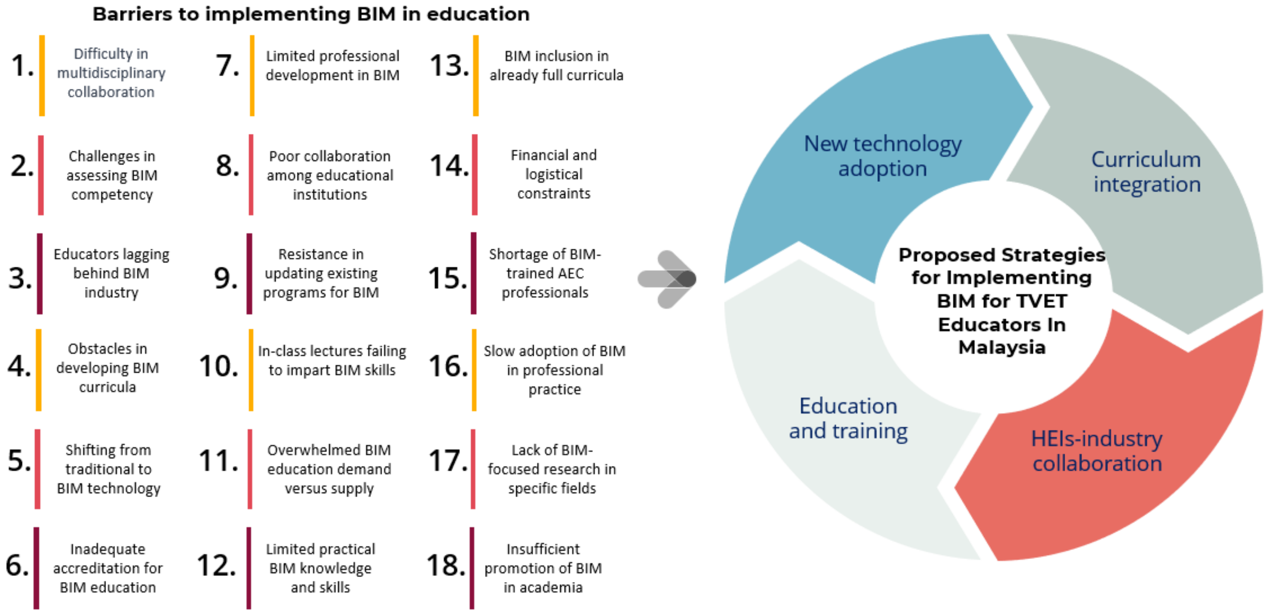


**Fig. 3.** The BIM barriers and proposed strategies for implementing BIM for TVET educators in Malaysia

## 4. Conclusion

Integrating BIM into the curriculum of Malaysian TVET institutions presents a multifaceted barrier that encompasses curriculum design, university-industry collaboration, specialised education, and the implementation of the latest technology. To bridge the gap between education and industry needs, a combined effort is required to expand a curriculum that now includes BIM theory and affords sensible application through workshops, collaborations, open-getting-to-know platforms, and undertaking-based totally gaining knowledge. The curriculum needs to strategically integrate the study of more than one software programme application to tackle interoperability troubles and facilitate the realistic utility of production information. University-enterprise collaboration emerges as an essential component, stressful every day, and effective communication to ensure the relevance and timeliness of BIM education. Such partnerships can catalyse the modernisation of the AEC enterprise, introducing an extra collaborative and technologically adept group of workers. Additionally, the curriculum has to sell self-studying and inspire a student-centred method, which aligns with the needs of the Industrial Revolution 4.0 workplace.

Despite the growing demand for BIM education, barriers remain in terms of teaching, curriculum delivery, knowledge, and alignment with industry standards. Addressing these barriers is essential to preparing a competent AEC workforce equipped with BIM capabilities. The findings of this study highlight the way forward, suggesting that Malaysian HEIs, as representatives of TVET institutions, can use these insights to make informed decisions on BIM implementation. Thereby, educators can better understand their capabilities, address educational barriers, and effectively develop strategies to address these challenges, resulting in a more robust and BIM-competent educational system in Malaysian TVET Institutions. In conclusion, this paper reviews the implementation of BIM for TVET Educators in Malaysia. It covers barriers and the strategies for implementing BIM. However, limitations may occur due to specific search keywords in databases. Moreover, coordination among institutions is essential to provide necessary standards and strengthen transversally between subjects. Perceived barriers and benefits of BIM implementation differ among institutions, and scientific literature should cooperate to find standard solutions for curriculum design and BIM implementation frameworks.

**Acknowledgements**
The author/s would like to thank Universiti Sains Malaysia and Politeknik Sultan Abdul Halim Mu'adzam Shah, Malaysia, for their continuous support of this study. The Ministry of Higher Education Malaysia funded this study under the Federal Government Scholarship Hadiah Latihan Persekutuan (HLP) of the Department of Polytechnic Education and Community College, Malaysia (PolyCC).

**References**
[1] Yunos, Jailani Md, Siti Nur Kamariah Rubani, Maizam Alias, Sri Sumarwati, Faizal Amin Nur Yunus, Hashima Hamid, and Fahmi Rizal. "Vocational pedagogical decisions of Malaysian and Indonesian non-engineering TVET teachers." *Journal of Technical Education and Training* 11, no. 3 (2019). https://doi.org/10.30880/jtet.2019.11.03.001
[2] Institut Maklumat & Analisis Pasaran Buruh (ILMIA), "Technical and Vocational Education and Training Final Report", (2018).
[3] Subri, Ummu Sakinah, Nurul Eizzaty Sohimi, Haryanti Mohd Affandi, Mohd Sallehuddin Mat Noor, and Faizal Amin Nur Yunus. "'Let's Collaborate': Malaysian TVET-Engineering Institution and Industry Partnership." *Journal of Technical Education and Training* 14, no. 2 (2022): 165-176.
[4] Amran, Aliza Che, Gede Pramudya Ananta, Mohd Ariff bin Mat Hanafiah, Adlan Ali, and Che Ku Nuraini Che Ku Mohd. "Development of the Malaysian skills certification for lecturers in tertiary TVET institutions." *Journal of Technical Education and Training* 12, no. 1 (2020).
[5] Md Yusoff, Ruzita, Anas Harun, and Ahmad Munzir. "Tvet in Malaysia: Capabilities and challenges as viable pathway and educational attainment." *Journal on Technical and Vocational Education* 5, no. 1 (2020).
[6] Nadya Subramaniam and Fauwaz Abdul Aziz. "Governance of TVET in Malaysia: Gaps and opportunities for researchers", (2023). www.tvet-online.asia
[7] CIDB. "The BIM Guide 1st edition", (2016).
[8] Huang, Yilei. "A review of approaches and challenges of BIM education in construction management." *Journal of Civil Engineering and Architecture* 12, no. 6 (2018): 401-407. https://doi.org/10.17265/1934-7359/2018.06.001
[9] Gartoumi, Khalil Idrissi, and Stéphane Cédric Koumetio Tékouabou. "Smart-BIM for Smart Cities: Issues and Challenges." In *E3S Web of Conferences*, vol. 418, p. 03004. EDP Sciences, 2023. https://doi.org/10.1051/e3sconf/202341803004
[10] Idrissi Gartoumi, Khalil, Mohamed Aboussaleh, and Smail Zaki. "Building information modelling a key for construction industry recovery post-Covid-19." In *Proceedings of the Institution of Civil Engineers-Engineering Sustainability*, vol. 176, no. 2, pp. 82-93. Thomas Telford Ltd, 2022. https://doi.org/10.1680/jensu.22.00014
[11] Shehzad, Hafiz Muhammad Faisal, Roliana Binti Ibrahim, Ahmad Fadhil Yusof, Khairul Anwar Mohamed Khaidzir, Muhammad Mahboob Khurshid, and Farah Zeehan Othman. "Building Information Modelling Adoption Model for Malaysian Architecture, Engineering and Construction Industry." In *International Conference of Reliable Information and Communication Technology*, pp. 999-1008. Cham: Springer International Publishing, 2020. https://doi.org/10.1007/978-3-030-70713-2_89
[12] Othman, Idris, Yasser Yahya Al-Ashmori, Yani Rahmawati, YH Mugahed Amran, and Mohammed Ali Mohammed Al-Bared. "The level of building information modelling (BIM) implementation in Malaysia." *Ain Shams Engineering Journal* 12, no. 1 (2021): 455-463. https://doi.org/10.1016/j.asej.2020.04.007
[13] Brahim, Juliana, Seri Nanisa Sima Yusoff, and Zainidi Mat Yusoff. "Incorporation of building information modelling (BIM) in Malaysian higher education institutions: a review." *Built Environment Journal (BEJ)* 18, no. 1 (2021): 15-22. https://doi.org/10.24191/bej.v18i1.10404
[14] Alshamrani, Othman Subhi. "Construction cost prediction model for conventional and sustainable college buildings in North America." *Journal of Taibah University for Science* 11, no. 2 (2017): 315-323. https://doi.org/10.1016/j.jtusci.2016.01.004

[15] Lame, Guillaume. "Systematic literature reviews: An introduction." In *Proceedings of the design society: international conference on engineering design*, vol. 1, no. 1, pp. 1633-1642. Cambridge University Press, 2019. https://doi.org/10.1017/dsi.2019.169
[16] Phillips, Tina, Norman Porticella, Mark Constas, and Rick Bonney. "A Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science." *Citizen Science: Theory & Practice* 3, no. 2 (2018). https://doi.org/10.5334/cstp.126
[17] Sinoh, Saznizam Sazmee, Faridah Othman, and Zainah Ibrahim. "Critical success factors for BIM implementation: a Malaysian case study." *Engineering, Construction and Architectural Management* 27, no. 9 (2020): 2737-2765. https://doi.org/10.1108/ECAM-09-2019-0475
[18] Munianday, Praveena, Rahimi A. Rahman, and Muneera Esa. "Case study on barriers to building information modelling implementation in Malaysia." *Journal of Facilities Management* 21, no. 4 (2023): 511-534. https://doi.org/10.1108/JFM-10-2021-0132
[19] Hedayati, Ali, S. R. Mohandes, and C. Preece. "Studying the obstacles to implementing BIM in educational system and making some recommendations." *Journal of Basic Applied Science Research* 5, no. 3 (2015): 29-35.
[20] Puolitaival, Taija, and Perry Forsythe. "Practical challenges of BIM education." *Structural Survey* 34, no. 4/5 (2016): 351-366. https://doi.org/10.1108/SS-12-2015-0053
[21] Waqar, Ahsan, Abdul Hannan Qureshi, and Wesam Salah Alaloul. "Barriers to building information modeling (BIM) deployment in small construction projects: Malaysian construction industry." *Sustainability* 15, no. 3 (2023): 2477. https://doi.org/10.3390/su15032477
[22] Zhang, Jingxiao, Meirong Zhang, Pablo Ballesteros-Pérez, and Simon P. Philbin. "A new perspective to evaluate the antecedent path of adoption of digital technologies in major projects of construction industry: A case study in China." *Developments in the Built Environment* 14 (2023): 100160. https://doi.org/10.1016/j.dibe.2023.100160
[23] Gusenbauer, Michael, and Neal R. Haddaway. "Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources." *Research synthesis methods* 11, no. 2 (2020): 181-217. https://doi.org/10.1002/jrsm.1378
[24] Shaffril, Hayrol Azril Mohamed, Asnarulkhadi Abu Samah, and Syafila Kamarudin. "Speaking of the devil: a systematic literature review on community preparedness for earthquakes." *Natural hazards* 108, no. 3 (2021): 2393-2419. https://doi.org/10.1007/s11069-021-04797-4
[25] Kraus, Sascha, Matthias Breier, and Sonia Dasí-Rodríguez. "The art of crafting a systematic literature review in entrepreneurship research." *International Entrepreneurship and Management Journal* 16 (2020): 1023-1042. https://doi.org/10.1007/s11365-020-00635-4
[26] Kitchenham, Barbara, and Stuart Charters. "Guidelines for performing systematic literature reviews in software engineering version 2.3." *Engineering* 45, no. 4ve (2007): 1051.
[27] Whittemore, Robin, and Kathleen Knafl. "The integrative review: updated methodology." *Journal of advanced nursing* 52, no. 5 (2005): 546-553. https://doi.org/10.1111/j.1365-2648.2005.03621.x
[28] Braun, Virginia, and Victoria Clarke. "Using thematic analysis in psychology." *Qualitative research in psychology* 3, no. 2 (2006): 77-101. https://doi.org/10.1191/1478088706qp063oa
[29] Flemming, Kate, Andrew Booth, Karin Hannes, Margaret Cargo, and Jane Noyes. "Cochrane Qualitative and Implementation Methods Group guidance series—paper 6: reporting guidelines for qualitative, implementation, and process evaluation evidence syntheses." *Journal of clinical epidemiology* 97 (2018): 79-85. https://doi.org/10.1016/j.jclinepi.2017.10.022
[30] Kimber, Melissa, Jennifer Couturier, Katholiki Georgiades, Olive Wahoush, and Susan M. Jack. "Ethnic minority status and body image dissatisfaction: A scoping review of the child and adolescent literature." *Journal of Immigrant and Minority Health* 17 (2015): 1567-1579. https://doi.org/10.1007/s10903-014-0082-z
[31] Agirbas, Asli. "Teaching construction sciences with the integration of BIM to undergraduate architecture students." *Frontiers of Architectural Research* 9, no. 4 (2020): 940-950. https://doi.org/10.1016/j.foar.2020.03.007
[32] Alizadehsalehi, Sepehr, Ahmad Hadavi, and Joseph Chuenhuei Huang. "Assessment of AEC students' performance using BIM-into-VR." *Applied Sciences* 11, no. 7 (2021): 3225. https://doi.org/10.3390/app11073225
[33] Aziz, N. M., P. X. Yap, and N. Zainon. "Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution." *International Journal of Innovation, Creativity and Change* 9, no. 7 (2019): 37-50.
[34] Babatunde, Solomon Olusola, Damilola Ekundayo, Olubola Babalola, and Jumoke Aduramigba Jimoh. "Analysis of the drivers and benefits of BIM incorporation into quantity surveying profession: Academia and students' perspectives." *Journal of Engineering, Design and Technology* 16, no. 5 (2018): 750-766. https://doi.org/10.1108/JEDT-04-2018-0058
[35] Casasayas, Oskar, M. Reza Hosseini, D. J. Edwards, Sarah Shuchi, and Mahmuda Chowdhury. "Integrating BIM in higher education programs: Barriers and remedial solutions in Australia." *Journal of Architectural Engineering* 27, no. 1 (2021): 05020010. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000444

[36] Chen, Ke, Weisheng Lu, and Jing Wang. "University–industry collaboration for BIM education: Lessons learned from a case study." *Industry and Higher Education* 34, no. 6 (2020): 401-409. https://doi.org/10.1177/0950422220908799

[37] Deniz, Gulbin Ozcan. "Emerging cad and bim trends in the aec education: An analysis from students' perspective." (2018).

[38] Dan, Wang, Radzi Ismail, Tan Jo Yen, Khoo Terh Jing, Kan Zhangfei, Zhang Yunbo, Mohd Wira Mohd Shafiei, and Ha Chin Yee. "Digital Technology Fluency and BIM Learning Environment in Undergraduate Construction Management." *International Journal on Advanced Science, Engineering & Information Technology* 13, no. 1 (2023). https://doi.org/10.18517/ijaseit.13.1.16946

[39] Isanovic, Hatidza, and Birgül Çolakoğlu. "Students' perceptions of BIM learning scenario in architectural education." *A| Z ITU Journal of the Faculty of Architecture* 17, no. 3 (2020): 195-209. https://doi.org/10.5505/itujfa.2020.87528

[40] Ismail, Aimi Sara, Kherun Nita Ali, Nur Emma Mustaffa, Noorminshah A. Iahad, and Badiru Yunusa Yusuf. "Enhancing The Graduates'employability And Career Development Through Building Information Modelling Intensive Training." *International Journal of Built Environment and Sustainability* 6, no. 1-2 (2019): 91-99. https://doi.org/10.11113/ijbes.v6.n1-2.387

[41] Lassen, Ann Karina, Eilif Hjelseth, and Tor Tollnes. "Enhancing learning outcomes by introducing BIM in civil engineering studies–experiences from a university college in Norway." *Building Information Systems in the Construction Industry* (2018): 65. https://doi.org/10.2495/SDP-V13-N1-62-72

[42] Maharika, Ilya Fadjar, Achmad Irsan, Syarifah Ismailiyah Al Athas, Ariadi Susanto, Vendie Abma, and Yebi Yuriandala. "Building information modelling (BIM) adoption model for architectural education." *Journal of Design and Built Environment* 20, no. 3 (2020): 22-42. https://doi.org/10.22452/jdbe.vol20no3.2

[43] Nikolic, Dragana, Fadi Castronovo, and Robert Leicht. "Teaching BIM as a collaborative information management process through a continuous improvement assessment lens: a case study." *Engineering, Construction and Architectural Management* 28, no. 8 (2021): 2248-2269. https://doi.org/10.1108/ECAM-11-2020-1000

[44] Zhang, Jingxiao, Chuandang Zhao, Jun Wang, Hui Li, and Henk Huijser. "Evaluation framework for an interdisciplinary bim capstone course in highway engineering." *International Journal of Engineering Education* 36, no. 6 (2020): 1889-1900.

[45] Aziz, N. M., P. X. Yap, and N. Zainon. "Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution." *International Journal of Innovation, Creativity and Change* 9, no. 7 (2019): 37-50.

[46] Maharika, Ilya Fadjar, Achmad Irsan, Syarifah Ismailiyah Al Athas, Ariadi Susanto, Vendie Abma, and Yebi Yuriandala. "Building information modelling (BIM) adoption model for architectural education." *Journal of Design and Built Environment* 20, no. 3 (2020): 22-42. https://doi.org/10.22452/jdbe.vol20no3.2