Current Integrative Engineering
Volume 1, Issue 1, 1-22
DOI: 10.59762/cie570390541120231031122045

The Awareness Of Implementing Building Information Modelling (Bim) For Educators In Malaysia Tvet Institutions: A Systematic Literature Review

Nurul Hazalia Ismail*[1], Dr. Ernawati Mustafa Kamal[2]
Universiti Sains Malaysia

ABSTRACT

BIM technology has become trending in the Malaysian construction industry recently; numerous research studies identify the lack of professional skills in BIM application as a primary reason for adopting BIM in industries. Facing professional skill issues, BIM education is related to cooperation with the industry, universities, technical colleges, and communities by practising and specialising in training. This requires studying specific issues in BIM implementation among educators in TVET institutions, and coordination with industry professionals is necessary to unveil the present status of BIM in each of the professions. The Malaysian TVET Institutions are responding to these barriers by implementing BIM to the institution with the curriculum design, collaboration extending to multiple professionals in the industries at the same time, and providing adequate education and training to their educators. With this objective, a systematic literature review was carried out on WOS and SCOPUS guided by the ROSES methodology. Inclusion and exclusion criteria were selected based on keywords, abstracts, and the full content of the articles. In the end, 14 articles were thoroughly studied, the integration and evaluation methods analysed, and results obtained. The analysis shows the empirical evidence to identify the awareness and determine the barriers to implementing BIM among educators in Malaysia TVET Institutions. Finally, recommended strategies for mitigating barriers to implementing BIM for educators were identified

Keywords: Educators; BIM awareness; AEC; Malaysia TVET Institutions; systematic literature review

Introduction

Background

Building Information Modelling (BIM) is defined as the building, including its components and information about properties such as function, form, material and processes for the building lifecycle. Building Information Modelling (BIM) is defined as the building, including its components and information about properties such as function, form, material and processes for the building lifecycle. It has been observed as a tool to digitise the representation of a building as a computer-generated model that allows for embedding important information in BIM models (Sinoh et al., 2020). BIM, also known as computer-based technologies and the Internet of Things (IoT), has widely been adopted in the architecture, engineering and construction industry (AEC) to assist architects, engineers, and managers in achieving the best practice for the industry demands (Rafsanjani & Nabizadeh, 2021) The advantages of BIM have been proven to increase collaboration across these stages and improve communication between the stakeholders within the industry (Um et al., 2023). It has enabled architects, consultants and contractors to work autonomously and prevented stakeholders from individually and collectively participating in integrated project delivery (Bughio et al., 2021).

Nurul Hazalia Ismail
Universiti Sains Malaysia
Email: nurulhazalia@gmail.com

Moreover, conflicting information resulted from this occurrence, ultimately becoming the main reason for a series of problems that led to the project's failure, and all these loopholes can be closed by introducing and implementing BIM. BIM offers crucial improvements and innovations in build visualisation, project management and communication for the construction industry. As a result, construction plans are unreliable regarding their schedules, and the confidence of those involved in these schedules is reduced (Maglad et al., 2023). Therefore, BIM is widely used in the design stage in the construction industry (Kamaruzzaman et al., 2023) and provides information about the project, forming a reliable basis for decisions of the project lifecycle from the inception stage to the completion stage (Zima et al., 2020). BIM also effecti ely coordinates design and information communication between the construction teams and is a significant way of managing a project for the AEC (Valinejadshoubi et al., 2022)

For this reason, a study conducted by Manzoor et al. (2021) found that only 13% of government and private sectors implemented BIM in their organisations. Malaysia is still behind in adopting BIM technology in the industry. BIM implementation in Facility Management in Malaysia is relatively slow (Kamaruzzaman et al., 2023). Furthermore, the construction industry in Malaysia needs to progress as predicted and contribute the least to economic productivity. BIM adoption would be a vital factor in the breakthrough development of the construction industry in terms of the productivity and efficienc of the project delivery process (Ang Soon Ern et al., 2022). Therefore, implementing BIM will help fill the information gap and improve Malaysia's construction industry's productivity. As a new method, BIM presents several opportunities and challenges for the AEC industry. AEC is a term used to refer to the industry that encompasses the design, planning, and construction of buildings and infrastructure.

Moreover, due to the increased complexity of construction projects and advancements in computer technology, BIM has been integrated into the operations of the AEC industry (Ademci & Gundes, 2018). While in the initial entry phase of the adoption, the institution may formulate learning objectives and learning plans and develop courses/ modules that integrate BIM into the curriculum. The process-oriented teaching approach in the project-based course is the strategic entry point to understanding BIM (Wang & Leite, 2014; Maharika et al., 2020). A recent study conducted by (S. N. S. Yusoff et al., 2021) has found that the Government of Malaysia has started to put more initiatives to complement BIM in the education system by having MoUs with universities and provided to educators with a 5-month BIM Training program where the participants are awarded Professional Certificate TVET refers to Technical Vocational Education and Training as a higher educational institution that aims to produce students with the knowledge and diverse skills base for improving the quality to become skilled workers when venturing into the working world (Yunos et al., 2019). TVET is defined as an education and training process that has an occupational direction with significant emphasis on Industry practices that aims to produce a competent workforce in related fields to meet the socio and economic objectives of the country (Institut Maklumat & Analisis Pasaran Buruh (ILMIA), 2018). The institutions are the primary factor in forcing socio-economic development, decreasing unemployment issues and address in industrialisation on demands in the industry. Thus, Malaysia has taken numerous strategies and initiatives through the TVET providers to implement

TVET improvements, including designing and implementing industry-led curricula, upgrading teaching staff, and developing a portfolio of high-tech and high-value programs (R. M. Yusoff et al., 2020)

THE NEED FOR A SYSTEMATIC LITERATURE REVIEW

A systematic literature review (SLR) synthesises scientific evidence to answer a particular research question in a transparent and reproducible way while seeking to include all published evidence on the topic and appraising the quality of this evidence (Lame, 2019). Phillips et al. (2018) also identified that systematic literature reviews are rigorously designed and conducted literature reviews that aim to comprehensively search, identify, and appraise the quality of and synthesise all, assessing and summarising all high-quality research evidence to answer specific research questions. The reviews have the

potential for design research and address some critical issues. However, work is needed to define what review methods are appropriate for each type of research question in design research and to adapt guidance to the needs and specificities. A considerable amount of existing systematic review related to BIM implementation studies has been conducted globally. However, only a limited number of studies were executed within the context of BIM awareness among educators and TVET institutions. According to (Sinoh et al., 2020), a systematic nationwide survey on BIM in Malaysia still needs to be conducted. Further research in Malaysia should be aimed at better understanding the current state of BIM in the country before appropriate plans can be made for the widespread implementation of BIM (Sinoh et al., 2020). More research needs to be conducted by Malaysian academicians to identify the barriers in educational institutions, including recommendations to eliminate these obstacles in the education system (Hedayati et al., 2015). Meanwhile, Puolitaival & Forsythe, (2016) also identify the challenges of BIM education as the lack of teaching-learning resources, difficu y in finding between theory-practice, technology process and traditional-modern construction project management methods and skill professional academicians' development. The available literature heavily focused on BIM implementation in industries and students rather than educators. As highlighted by (Zhang et al., 2016), the lack of BIM education in tertiary studies has raised concerns worldwide as the demanding skill for BIM conduct increases. Implementing BIM in the education system is still piloted with these new technologies (Yilei Huang, 2018) 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. Given this gap in the literature, the current study aims to conduct an SLR that focuses explicitly on the awareness of implementing BIM for educators in Malaysia TVET Institutions. Throughout this approach, the empirical evidence to identifies and justifies the gaps and guides the direction for future research in this field. In progressing the review, driven by the leading research objectives;

- To identify the awareness level in implementing BIM for educators in Malaysian TVET Institutions.
- To determine barriers to implementing BIM for educators in Malaysian TVET Institutions.
- To recommend strategies for mitigating barriers in implementing BIM for educators.

Methodology

This section explains the fi e (5) main sub-sections: The Review Protocol-ROSES, formulation of the research objectives, systematic searching strategies, assessing the methodological quality or rigour of the included studies, the systematic review process, and data abstraction and analysis in the current research.

The Review Protocol – ROSES

The ROSES review protocol guided the present study. ROSES, or reporting standards for Systematic Evidence Syntheses, are explicitly designed for systematic review and maps for the environmental management field (Haddaway et al., 2018). ROSES aim to prompt researchers to ensure they offer the right information with the correct level of detail. Based on this review protocol, appropriate research questions for the review are formulated. Then, the systematic searching strategy, which consists of three main sub-processes: identification, screening (inclusion and exclusion criteria) and eligibility, are explained. Then, the quality of the selected articles is presented on the strategy applied to ensure the quality of the articles to be reviewed. Lastly, the explanation of how the data were abstracted for the review and how the abstracted data were analysed and validated.

Formulation of the Research Objectives

The formulation of the research question for this study was based on PICo. PICo is a tool that assists authors in developing relevant research questions for the review. PICo is based on three main concepts: Population or Problem, Interest and Context. Based on these concepts, three main aspects in the study, namely Educators (Population), BIM Implementation (Interest) and Malaysia TVET Institution (context), are guided in formulating the main research title 'What are the Awareness of Implementing Building Information Modelling (BIM) for Educators in Malaysia TVET Institutions?'.

Systematic Searching Strategies
The systematic searching strategies process has three main functions: identification, screening, and eligibility.

Identification
The systematic review process in selecting several relevant articles for the present study consisted of three main stages. The first stage is the identification process to search any synonym, related terms, and variation for the main keywords for the study, namely Building Information Modelling, implementation, and Educator. It aims to provide more options for the selected database to search for related articles for the review. The keywords are developed based on the research question, and the identification process relies on an online thesaurus, ChatGPT and keywords used by past studies. Meanwhile, to enrich the existing keywords and develop the entire search string (based on Boolean operator, phrase searching, truncation, wild card, and field code functions) on the two primary databases, namely Scopus and Web of Science. These two databases be leading databases in a systematic literature review due to several advantages it possesses such as advanced searching functions, comprehensive controls of the articles' quality and multidisciplinary focus, including environment management-related studies (Martin-Martin et al., 2018; Gusenbauer & Haddaway, 2020). Consequently, search strings on Scopus

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"))

Table 1: The search string

and Web of Science database were developed in March 2023, as shown in Table 1, after all the relevant keywords managed to be determined.

Screening

This study screened all 197 selected articles by choosing the criteria for article selection, which is done automatically based on the sorting function available in the database. Screening is setting up inclusion or exclusion to be used as an article/ reference (Shaffril et al., 2021) As it is almost impossible for the researchers to review all the existing published articles, Kraus et al. (2020) suggested that the researchers should determine the range of periods capable of examining. Based on the search process on the selected database, it was realised that the number of studies related to BIM implementation has multiplied starting from 2018. Therefore, based on this, the timeline between 2018 and 2023 was selected as one of the inclusion criteria. Meanwhile, to ensure the quality of the review, only articles with empirical data published in a journal are included. Moreover, only articles published in English are incorporated into the study to avoid confusion in understanding. The inclusion and exclusion criteria as shown in Table 2. This process excluded 124 articles as they did not fit the inclusion criteria and removed 22 duplicated articles. The remaining 51 articles were used for the third process eligibility.

Eligibility

A total of 51 articles were prepared for the third stage of eligibility. At this stage, on a more critical note, the abstracts and the main contents of all the articles were examined thoroughly to ensure that they fulfilled the inclusion criteria and were fit to be employed in the present study to achieve the current research objectives. 14 remaining articles are ready to be analysed, as shown in Figure 1. something other than BIM implementation in the education system or Malaysia and TVET institutions.

Assessing the methodological quality or rigour of the included studies

The methodological quality stage was assessed to ensure that the methodology and analysis of the selected studies were completed satisfactorily (Shaffril et al., 2020). For this purpose, Primary Studies (PSs), the original research articles that address a specific research question, have been chosen. Quality assessment of PSs is an essential step in an SLR to determine the credibility and validity of the evidence presented in the studies by the experts. According to guidelines proposed by (B. Kitchenham & S. Charters, 2007), the quality of the articles is measured by the following Quality Assessment (QA)Criteria.
QA1: Is the purpose of the study clearly stated?
QA2: Is the interest and usefulness of the work presented?
QA3: Is the study methodology established?
QA4: Are the concepts of the approach clearly defined
QA5: Is the work compared and measured with other similar work?
QA6: Are the limitations of the work mentioned?

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

Table 2: Inclusion and exclusion criteria

The scoring procedure used to evaluate each QA is based on YES (Y) = 1, PARTLY (P) = 0.5 or NO (N) = 0. Based on this process, all authors agreed that all selected articles passed the minimum quality requirement of more than a 3.0 score. According to Robinson & Lowe (2015), the number of articles paper for SLR is usually less than 50 papers or often fewer than 10 to assess. Thus, in this SLR, 14 articles fulfilled all criteria with a score of more than 3 (Table 3) assessed.

Data Extraction and Analyses

The integrative review technique allowed diverse research designs (quantitative, qualitative, mixed-method) to be included in the review. According to Whittemore and Knafl (2005), the best way to synthesise or analyse integrative data is by using qualitative or mixed-method techniques that enable the researcher to conduct iterative comparisons of primary data sources. The present study selected the qualitative approach. Twenty articles were read thoroughly, particularly in the abstract, results, and discussion sections. The data extraction was conducted based on the research questions; it denotes that any data from the reviewed studies that can answer the research questions were abstracted and placed in a table. Subsequently, the thematic analysis was performed to identify themes based on efforts related to noting patterns and themes, clustering, counting, noting similarities, and relationships that existed within the abstracted data (Braun & Clarke, 2006). Thematic analysis is the most suitable for synthesising a mixed research design (integrative) (Flemming et al., 2018). It is a descriptive method that reduces the data in a flexible mode that merges with other data analysis techniques (Vaismoradi et al., 2013). The first data extraction step followed a qualitative approach with NVivo Plus version 14 software as a tool. The research question guided data mining, and contents were probed accordingly throughout the extraction process for the comparative content analysis of the codes. Themes and patterns were coded as they emerged. Therefore, the patterns among the abstracted data of all reviewed articles to four (4) principal codes and six (6) sub-codes were created and examined. The following process involved reviewing the accuracy of these themes, in this process to ensure their usefulness and accurate representations of the data.

Results

General findings and background of the studies included in the review

The analysis produced four (4) themes related to the awareness of implementing building information modelling (BIM) for educators in Malaysia TVET institutions, as shown in Table 4a (List of Articles) and Table 4b (Theme and Sub-theme). As observed in Table 4a, there is significant article information such as year of publication, article titles, names of the author/s and the journal names. The first theme is BIM overviews explained on drivers of implementing

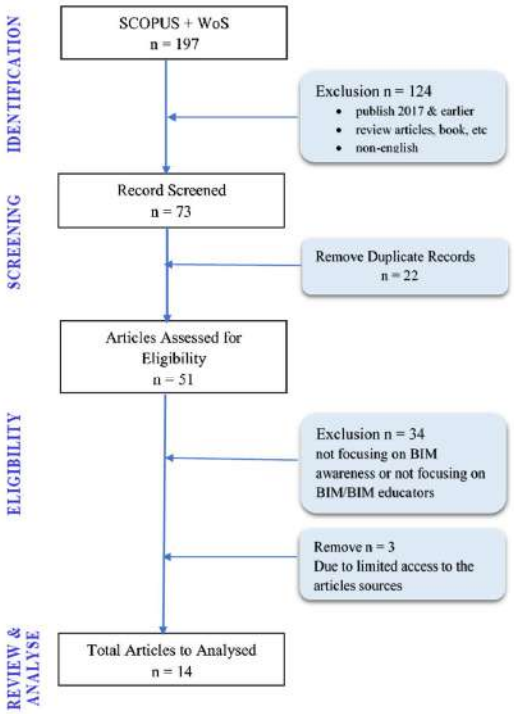

Figure 1: Flow diagram of the search process

BIM for AEC professions and the benefits of implementing BIM for the AEC Profession. The second theme is BIM awareness among BIM educators. Then, the barriers to implementing BIM in education and mitigating strategies for implementing BIM in educational institutions with four (4) sub-themes (curriculum integration, university-industry collaboration, education

and training and new technology adoption).

Article No	Author/s	Journal Title	Name of Journal
1	Agirbas, (2020)	Teaching construction sciences with the integration of BIM to undergraduate architenture students	Frontiers of Architectural Research
2	Alizadehsalehi et al., (2021)	Assessment of AEC Students' Performance Using BIM-into-VR	Multidisciplinary Digital Publishing Institute
3	Aziz, (2019)	Assessing BIM Education Level in Quantity Surveying Programe: A Survey in Malaysian Higher Institution	International Journal of Innovation, creativity and Change
4	Babatunde et al., (2018)	Analysis of the driver and benefits of BIM incorporation into quantity surveying profession Academia and students' perspectives	Journal of Engineering, Design and Technology
5	Casasayas et al., (2021)	Integrating BIM in Higher Education Programes: Barriers and Remedial Solutions in Australia	Journal of Architechtural Engineering
6	Chen et al., (2020)	University-industry collaboration for BIM education: Lessons learned from a case study	Industry and Higher Education
7	Commons & Ozean Denis, (2018)	Emerging CAD and BIM trends in the aec eduation: An analysis from students perspective	Journal of Information Technology in Construction
8	Den et al., (2023)	Digital Technology Fluency and BIM leaning Environment in Undergratuate Construction Management	International Journal on Advanced Science, Engineering and Information Technology
9	Isanoivic & Colakoglu, (2020)	Students' perceptions of BIM learning scenario in architectural eduacation	Journal of Faculty Architecture
10	Ismail et al., (2019)	Enhancing The Graduates' Employability and Career Development Through Building Information Modelling Intensive Training	International Journal of Built Environment & Sustainability
11	Lassen et al.,	Enhancing learning outcomes by introducing BIM in civil engineering studies- experiences from a university collage in Norway	International Journal of Sustainable Development and Planning
12	Maharika et al., (2020)	Building information Modelling (BIM) Adoption Model for Architectural Education	Journal of Design and Built Environment
13	Nikolie,(2021)	Teaching BIM as a collaborative information management process through a continuous improvement assessment lens: a case study	Engineering Construction & Architechtural Management
14	Zhang et al., (2020)	Evaluation Framework for an Interdisciplinary BIM Capstone course in Highway Engineering*	International Journal of Engineering Education

Table 4a: List of Articles

Author/s	Theme & Sub-themes							
	BIM overviews		BIM awareness among educators	The barriers to implementing BIM in education	Mitigating strategies for implementing BIM in educational institutions			
	Drivers of implementing BIM for AEC professions	The benefits of implementing BIM for the AEC Profession			Curriculum integration	HEIs-industry collaboration	Education and training	New technology adoption
Agirbas, (2020)		✔ (1)	✔ (1)					
Alizadehsalehi et al., (2021)	✔ (1)	✔ (1)		✔ (1)	✔ (1)			
Aziz, (2019)	✔ (1)	✔ (1)	✔ (2)	✔ (1)	✔ (1)		✔ (1)	✔ (1)
Babatunde et al., (2018)	✔ (1)	✔ (1)		✔ (1)			✔ (1)	
Casasayas et al., (2021)		✔ (1)	✔ (3)	✔ (7)		✔ (1)		✔ (1)
Chen et al., (2020)		✔ (1)	✔ (1)	✔ (4)	✔ (1)	✔ (1)		
Commons & Ozcan Deniz, (2018)	✔ (1)	✔ (1)	✔ (1)		✔ (1)			✔ (1)
Dan et al., (2023)		✔ (1)	✔ (2)		✔ (1)			
Isanović & Çolakoğlu, (2020)	✔ (1)	✔ (2)	✔ (3)	✔ (1)		✔ (1)		
Ismail et al., (2019)		✔ (1)	✔ (2)	✔ (2)	✔ (2)			
Lassen et al., (2018)				✔ (2)	✔ (2)			
Maharika et al., (2020)		✔ (1)	✔ (5)	✔ (3)	✔ (1)	✔ (1)	✔ (1)	✔ (4)
Nikolic, (2021)				✔ (1)				✔ (1)
Zhang et al., (2020)			✔ (2)	✔ (2)		✔ (1)	✔ (1)	

Table 4b: Theme and Sub-theme

The developed themes

BIM Overviews

Drivers of implementing BIM for AEC professions BIM is an essential driver of the Architecture, Engineering and Construction (AEC) profession as the clients demand to use BIM in their projects. Babatunde et al. (2018) mentioned that BIM provides fast, effecti e and efficient quantity take-off and cost estimation; improves cost database management, which reduces loss of information; produces reliable and accurate quantities as well as competitive cost estimates; enhances communication and collaboration amongst team members; time savings in the preparation of estimating costs; and it generates accurate cost estimates for various design alternatives, respectively. In addition, this study finding affirms potential for BIM use by quantity surveyors for such tasks as quantity take-offs, estimation and cost management in a collaborative project environment (Babatunde et al., 2018). According to Aziz (2019), implementing BIM among AEC professionals is essential as embracing BIM can increase the cost-effecti eness and value of construction processes, and technology has increased the demand for these professions with BIM skills and knowledge. Through the established university–industry collaboration, the university recognised the industry's needs and the degree of practical knowledge necessary regarding BIM implementation. At the same time, the industry partner also benefited from the academic knowledge of the collaboration (Chen et al., 2020). As the implementation of BIM in the AEC industry is rapidly increasing, construction players must possess high proficiency in BIM and competence in using relevant software applications. BIM has led to the dependency on technological usage to manage data for delivery and collaboration between construction parties. BIM technology and software applications could be considered a symbiotic relationship, where the software applications used in the AEC industry could only be developed parallel to the development of BIM technology while implementing BIM in a construc

tion project could only be successful by employing suitable software applications(Ismail et al., 2019). Various software applications are being developed in the market to support the implementation of BIM in the AEC industry (Ismail et al., 2019). BIM software availability and affor - ability, awareness of BIM tangible benefits, and clients' demand for the use of BIM in their projects are essential drivers of the AEC profession (Babatunde et al., 2018). Due to the increased complexity of construction projects and advancements in computer technology, integrating BIM and VR technology can develop workflow efficiency through enhanced architecture and engineering programs to become leaders of the AEC industry (Alizadehsalehi et al., 2021). However, the shortage of AEC professionals trained in BIM and VR is still a barrier to collaborative working practice in this industry(Ismail et al., 2019). Furthermore, in a research study conducted by Ismail et al. (2019) confirmed that BIM-into-VR usability and efficiency in improving students' main learning performance characteristics: Learnability, Interoperability, Visualization, Real-world, Interaction, Creativity, Motivation, and Comfort. It also offer suggestions to AEC educators and students in implementing BIM-into-VR in different courses and creating a roadmap for their future as professionals in the AEC industry. Commons & Ozcan Deniz (2018) also found that construction players prefer BIM to CAD regarding the friendliness of the user interface, help functions, and the self-detection of mistakes and also revealed that most players needed a BIM speciality course with Construction Management (CM), Structure, and Mechanical-Electrical-Plumbing (MEP) areas.

The benefits of implementing BIM for the AEC Profession

BIM has led to the dependency on technological usage to manage data for delivery and collaboration between construction parties (Ismail et al., 2019). A research study conducted by Babatunde et al. (2018) found that BIM benefits are perceived importance of BIM among industry professionals. This study also highlighted that BIM provides fast, effecti e and efficient quantity take-off and cost estimation; improves cost database management which reduces loss of information; produces reliable and accurate quantities as well as competitive cost estimates; enhances communication and collaboration amongst team members; time savings in the preparation of estimating costs; and it generates accurate cost estimates for various design alternatives, respectively. According to (Alizadehsalehi et al., 2021), BIM is also a database of information that creates a multi-dimensional knowledge resource and model, swiftly becoming the standard process for communicating all stages of AEC as BIM is a powerful tool for designing a high-quality 3D model; analyse various design options; detect clashes among different elements; perform energy simulation; plan and schedule; achieve quantity take off, estimate cost, and generation of procurement plans; coordinate a model among various project stakeholders and improve communication among project stakeholders; visualise the as-built model; enhance the quality of inspection; and facility management. BIM encourages all stakeholders to participate in and collaborate to achieve a high-quality product in all project phases. The BIM software availability and affor ability, awareness of BIM tangible benefits, and clients' demand for the use of BIM in their projects and significant differences could be attributed to the maturity of the respondents concerning the BIM implementation (Babatunde et al., 2018). Thus, specifying, articulating, and presenting a significant precision and transparency level in BIM models' consistency and content is essential (Alizadehsalehi et al., 2021)

BIM Awareness among Educators

BIM education is always interdisciplinary, and the focus has shifted to research into teaching frameworks for BIM education (Zhang et al., 2020). Since 2010, ArchiCAD has been considered the initial version of BIM and in 2013, the curriculum formalised the model in which it became compulsory for students to have the ability to operate BIM (Maharika et al., 2020). Many scholars have studied integrating BIM features into the original curriculum in the existing research, but evaluating such integration is under-researched (Zhang et al., 2020). A study conducted by (Isanović & Çolakoğlu, 2020) has raised local BIM awareness and knowledge, which will open the way to its wider adoption among the architectural education

community in Turkey. The study addresses the need, builds on the current scholarly discussion about BIM adoption in architectural education, and finds the difficultie in recommending any single model or curricular change in education. However, by adding a further dimension to these core criteria, the institution can develop the vision of BIM as part of its strategic development plans by identifying problems internally and formulating action plans for BIM. It should consistently implement BIM (Maharika et al., 2020). Meanwhile, (Commons & Ozcan Deniz, 2018) research study revealed that a BIM speciality course with Construction Management (CM), Structure, and Mechanical-Electrical-Plumbing (MEP) areas helps to improve the learning outcomes of CAD/BIM courses to help students in their learning process better, and works as a guideline for educators on how to design and teach CAD/BIM courses simultaneously by considering the learning process and perspectives of students. Furthermore, BIM is seen as an opportunity to improve architectural education by helping to resolve some of its existing issues (Isanović & Çolakoğlu, 2020). When BIM is integrated with the teaching of introductory construction courses within architecture degree programs, the students understand the building system principles simply and effecti ely (Agirbas, 2020). Both universities and industry believe in the capacity of BIM to significantly transform the global AEC industry (Chen et al., 2020). Moreover, BIM is going through fast-paced innovation cycles where rapid changes and new features occur. The majority of the universities, about 62.5%, have partially incorporated BIM into the curriculum, and another 37.5% of universities have fully incorporated and embedded BIM into their quantity surveying module or program (Aziz, 2019). The newest effort to integrate BIM into the learning culture was made during the formulation of the architecture and civil engineering in the new 2020 curriculum, and BIM culture has become a backbone for the new curriculum's learning outcomes responding to the new business and technology in construction industries (Maharika et al., 2020). The same studies also mentioned to all lecturers, technical staff members, and students the importance of BIM in the needed institutional change towards innovation. Meanwhile, Casasayas et al. (2021) conducted a research study at Australian universities that is somewhat antiquated and that research and development teams in the Australian BIM industry are ahead of universities. However, BIM fundamentals are grounded in collaboration and knowledge sharing (Casasayas et al., 2021). However, the interest and awareness of BIM and its implementation in practice and academia vary significantly from country to country (Maharika et al., 2020). Thus, the Malaysian government has highly encouraged the application of BIM to transform the Malaysian construction industry to a higher level. Moreover, the collaboration module provides a collaborative environment where students from different disciplines can share their perspectives on a project (Aziz, 2019). Although a research study by Dan et al. (2023) founds that numerous universities have integrated BIM into their curricula using various approaches and teaching methods, there is no commonly accepted approach to teaching BIM in Architecture, Engineering, and Construction (AEC) programs. From the result findings, it was found that the respondents have less knowledge of the BIM software. For future research, the focus can be shifted to other BIM competencies, such as the managerial, functional, technical, and support aspects of BIM. Another study by (Casasayas et al. (2021) also mentioned the importance of digital engineering and information, after which the advice was used to update the existing curriculum. The gap between industry know-how and academic pontification is all too apparent. However, now it has been clear that if the industry were to understand the challenges educators face, their input would provide added confidence to educators (Casasayas et al., 2021). Hence, the employers were impressed with their efforts to learn more than the academic programme had offered. Although the introduction to BIM was included in Information Technology in Construction subject, the students could not visualise the adoption of BIM in a construction project and were introduced the participants to the proper implementation of BIM in a real-time construction project. The training also provides them with awareness of the importance of collaborative working in the BIM environment. It also provides an extensive introduction to the BIM working environment, equipped with additional knowledge and skills currently not adopted

in academic programmes (Ismail et al., 2019).

The Barriers to Implementing BIM in Education

A study conducted by (Maharika et al., 2020) found that most of the current models on BIM adoption are directed toward the area of construction industries (consultant firms and contractors) and less toward higher education institutions, mainly concerning experimentation on curricular integration and the lack of general concepts of integration. Zhang et al. (2020) identified limited studies devoted to improving BIM education in highway engineering. Although the difficultie for educators to assess whether students are competent in certain BIM content mainly refer to vertical curriculum integration issues associated with educators, which were referred to as barriers to BIM education by a majority of participants, educators lag behind Industry Practices BIM is currently going through fast-paced innovation cycles where changes and new features occur at a rapid pace (Casasayas et al., 2021). The root causes of barriers that the efforts to establish effective BIM education programs would act as the driver toward identifying the top priority areas to manage the required reform (Casasayas et al., 2021). According to (Babatunde et al., 2018), the importance of industries may be the same or different from education counterparts. BIM implementation in engineering education, especially in architectural education, is currently available, as we revealed in this study. Consequently, the current BIM is advancements, and the lack of collaboration among Higher Education Institutions is a barrier identified to obstruct enhanced awareness of leading BIM (Zhang et al., 2020). Meanwhile, a case study conducted by Chen et al. (2020) found that the university educator helped the industry representatives identify how best their involvement could help students consolidate their BIM knowledge and support understanding professional content, the primary learning outcome. Many established practitioners struggle to keep up with the development, and there is a need for edu cated users (Isanović & Çolakoğlu, 2020). The current BIM Education level in the AEC programme in Malaysian Higher Education System is still minimal. The higher education institution hardly fulfilled the aspects of the management categories due to the difficultie of arranging a multidiscipline collaboration with other departments such as architecture, planning, building surveying, engineering, and other built environment-related disciplines (Aziz, 2019). Additionally, the current shortage of AEC professionals trained in BIM and VR is still a barrier to collaborative working practice in this industry, and the digital computer technological revolution continues to increase in the AEC industry, the impact of their extensive applications for training and educational objectives is of interest (Alizadehsalehi et al., 2021). Furthermore, Maharika et al. (2020) also found some specific barriers were the lack of IT infrastructure, BIM resource-intensive; lack of government direction; the cost of staff lecturers training; availability of qualified staff to take BIM courses; the need to continually upgrade the BIM software; and the lack of accreditation standards and requirements to guide the implementation of BIM within a curriculum. However, demand from the industry to implement BIM in an already packed curriculum for higher engineering education is also one of the barriers to educators as the capability to learn expeditiously as the assignment provided them with real-world problems (Lassen et al., 2018). Although, the knowledge in BIM management, coordination and collaboration was also limited (Ismail et al., 2019). In BIM education, constructing a BIM curriculum is crucial and conducive to a theoretical understanding of emerging technologies for students of different majors and mastering software operation and team cooperation (Zhang et al., 2020). Casasayas et al. (2021) found that the significant barriers identified oscillated around the various dimensions of change management and the problems associated with shifting from traditionally taught programs to digital visualisations and coding inherent within BIM. Teachers' lack of maturity and expertise also can result in poor learning and teaching outcomes (Isanović & Çolakoğlu, 2020). Thus, the difficultie in transforming existing programs, a lack of instructors with sufficien practical knowledge, and misalignment of educational outcomes and industry needs (Chen et al., 2020). Also, the educator admitted that traditional in-class lectures focused heavily on theory and struggled to guarantee skill development and collaborative practice with the

involvement of the industry partner allowed students to experience a real-world work environment (Chen et al., 2020). The rapidly growing demand for BIM education remains overwhelmed and stuck by various issues related to pedagogical design, course delivery, lack of sufficien expertise and, particularly, the misalignment of educational outcomes and industry needs (Chen et al., 2020). BIM education faces several challenges, such as difficultie transforming existing programs, a lack of instructors with sufficien practical knowledge and misalignment of educational outcomes and industry needs. Many educators thus advocate university-industry collaboration, but this effort is hampered by unanswered questions, including when, what and how both parties can contribute to the collaboration to achieve a win-win situation (Chen et al., 2020).

Mitigating Strategies for Implementing BIM in Educational Institutions

Curriculum Design

In moving towards the next level, teaching strategies such as workshops, collaboration, open-learning platforms and project-based learning strategies should be adopted to embed BIM into the curriculum (Aziz, 2019). Educational institutions are exploring strategies to incorporate BIM education in their undergraduate curriculum. The criteria of the curriculum must also involve the process of integration (Maharika et al., 2020). Instead of integrating BIM into the AEC profession, it was suggested that BIM-based curricula should be developed where construction knowledge is fused into these curricula (Lassen et al., 2018). Although, the most important outcome of the entire process is the need to embrace both CAD and BIM in the AEC curriculum by following the results and guidelines presented in this study to develop CAD/BIM courses (Commons & Ozcan Deniz, 2018). Hence, the students must learn several software applications to deal with the interoperability issue, from a 3D/BIM-based to a VR-enabled model (Alizadehsalehi et al., 2021). BIM is not simply a new software that can support the entire construction project and reach the full potential of BIM education; BIM should be implemented considerably (Dan et al., 2023). The educators suggested that the order of educational activities could be adjusted more appropriately for the next iteration of BIM education (Chen et al., 2020). A need for alternative ways to include BIM in the curriculum while at the same time strengthening – rather than supplanting - the traditional engineering subjects (Lassen et al., 2018). Hence, one of the initial efforts to integrate BIM education into the HEIs curricula in Malaysia is that industry involvement in the training helps establish a good relationship between industry and HE institution, subsequently opening the opportunity for an internship programme in BIM-based projects in the future (Ismail et al., 2019).

University-Industry Collaboration

Through the established university-industry collaboration, the university recognised the industry's needs and the degree of practical knowledge necessary regarding BIM implementation (Chen et al., 2020). A research study conducted by Casasayas et al. (2021), which focuses on Integrating BIM into Higher Education Institutions (HEIs), determined that without investment and collaboration between industry and government, HEIs cannot manage the change needed to run effecti e BIM training programs. According to Chen et al. (2020), BIM educators need to maintain regular and effecti e bi-directional communication with the industry despite recognising the fundamental questions that remain unanswered regarding what to educate, when to implement it in the curriculum and how to implement the collaboration in pedagogical design and course delivery, especially with the industry partners, mainly the major BIM vendors, will have a vested interest in this collaboration. Moreover, the collaboration of two parties became a fundamental course ingredient, not an addon or novelty disconnected from the core objectives of BIM education (Chen et al., 2020). Establishing a dynamic and continuous collaboration between professionals and the HEIs sector is the way forward in transforming the traditional structure of the AEC industry into a more collaborative and technological approach (Ismail et al., 2019). Collaboration between industrial practitioners and HEIs must be done more vigorously to help educators guide the students and provide access to BIM-based project information (Ismail

et al., 2019). This strategy is defined through an exchange of experience between the academic world and practice to simulate professional practice in the university. In addition, they promote self-learning and a study-centred approach, which are critical requirements of 21st-century curricula (Isanović & Çolakoğlu, 2020).

Education and Training

Trained educators and supporting staff members for the successful implementation of BIM teaching and learning must be prepared and provide availability of schemes to strengthen their competencies in skills (Maharika et al., 2020). Therefore, improving the educational paradigm and guiding civil colleges and universities to train students in BIM-based skills is imperative. To efficiently and accurately improve BIM, the particularity of this BIM course lies in its strong practicality, so it also needs to be combined with opportunities for practical application besides the training (Zhang et al., 2020). Future educators can also consider adding BIM construction technology and BIM operation and maintenance management to the capstone to enrich the complete cycle management of BIM (Zhang et al., 2020). Thus, industry and education, including students, need to improve their knowledge and skills in BIM and apply BIM to their daily practices (Babatunde et al., 2018).

New Technology Adoption

Accelerating the change toward innovation and multidisciplinary and interprofessional support for collaboration is essential for this final stage of the adoption of BIM in education (Maharika et al., 2020). A new module may need to be created that combines students from multidisciplines in equipping them with BIM technology skills, and the current BIM education level in the AEC profession falls within the infused level where the BIM knowledge and skills are restricted in terms of collaboration and applying BIM knowledge and skills practically (Aziz, 2019). Experts and BIM implementers suggested that the model may show a comprehensive view of higher education dimensions of BIM adoption in HEIs and may begin to develop a vision, strategy and roadmap for the integration of BIM in the academic environment as soon as possible as the gap is widening between education and the demand of AEC industry (Maharika et al., 2020). The model implies the importance of infrastructure, technology, and supporting human resources not only within but also from outside the organisation to develop a multidisciplinary community in operation, technical and nontechnical solutions, and research, and the readiness of this infrastructure will be closely related to the readiness of trained staff in the organisation (Maharika et al., 2020). Technology and infrastructure, the readiness of skilled trainers or human resources, and knowledge organisation that support the entire process ranging from the preparation, learning process, evaluation, and decision (Maharika et al., 2020). Furthermore, they also acquired and improved their technical skills using Autodesk Revit, AutoCAD, Naviswork Manage and Microsoft Project, which benefit their employment (Commons & Ozcan Deniz, 2018). Moreover, accreditation bodies and professional institutions must be key players to facilitate knowledge transfer between industry and universities. They must reflect the needs and requirements of the industry to the universities and ask for the transformation of courses and programs to accommodate such changes as conditions for accreditation (Casasayas et al., 2021).

Discussion

This part attempts to discuss the research objectives and the results obtained from this research study: 1. To identify the awareness level in implementing BIM for educators in Malaysian TVET Institutions. The awareness level was made by considering all the data articles analysed as results in section 3. Thus, general awareness of BIM implementation among educators was found. From the 14 articles analysed, 10 articles discussed the awareness of implementing BIM among educators in educational institutions. The results are shown in Table 5a – Educators' Awareness Level in Educational Institutions. 2. To determine barriers to implementing BIM for educators in Malaysian TVET Institutions. In the results, most of the barriers that arise in implementing BIM for educators were determined as shown in Table 5b – The Barriers in Implementing BIM. By understanding the awareness and barriers to implementing BIM among educators, the strategies for mitigating the barriers as in the research ob

Author/s	Journal Title	No of reading found in article	BIM awareness among educator/s
Agirbas, (2020)	Teaching construction sciences with the integration of BIM to undergraduate architecture students	✔ (1)	When BIM is integrated with the teaching of introductory construction courses within architecture degree programs, the students understand the building system principles simply and effectively
Aziz, (2019)	Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution	✔ (2)	1. BIM is going through fast-paced innovation cycles where rapid changes and new features occur. The majority of the universities, about 62.5%, have partially incorporated BIM into the curriculum, and another 37.5% of universities have fully incorporated and embedded BIM into their quantity surveying module or program 2. The Malaysian government has highly encouraged the application of BIM to transform the Malaysian construction industry to a higher level. Moreover, the collaboration module provides a collaborative environment where students from different disciplines can share their perspectives on a project
Casasayas et al., (2021)	Integrating BIM in Higher Education Programs: Barriers and Remedial Solutions in Australia	✔ (3)	1. BIM industry are ahead of universities 2. The importance of digital engineering and information, after which the advice was used to update the existing curriculum 3. The industry were to understand the challenges educators face, their input would provide added confidence to educators
Chen et al., (2020)	University–industry collaboration for BIM education: Lessons learned from a case study	✔ (1)	Universities and industry believe in the capacity of BIM to significantly transform the global AEC industry
Commons & Ozcan Deniz, (2018)	Emerging CAD and BIM trends in the aec education: An analysis from students' perspective	✔ (1)	Revealed that a BIM speciality course with Construction Management (CM), Structure, and Mechanical-Electrical-Plumbing (MEP) areas helps to improve the learning outcomes of CAD/BIM courses to help students in their learning process better, and works as a guideline for educators

Table 5a

jective 3. To recommend strategies for mitigating barriers to implementing BIM for educators were obtained. These recommendations are detailed in Table 5c - Strategies to Mitigate Barriers.

From the results, no articles mentioned Malaysian TVET Institutions; however, higher education institutions or universities represent the Malaysian TVET institution accordingly, as TVET refers to Technical Vocational Education and Training as a higher educational institution that aims to produce students with the knowledge and diverse skills base for improving the quality to become skilled workers when venturing into the working world (Yunos et al., 2019). These results can assist in decision-making for BIM implementation in Malaysian TVET Institutions. Hence, this led to the best understanding of the TVET's educator's ability to implement BIM in education, address the barriers, and be ready with strategies to mitigate the obstacles in education.

Author,s	Journal Title	No of Reading Found in article	The barriers to implementing BIM in education
Isanovic & Colakoglu,(2020)	students' perceptions of BIM learning scenario in architectural eduaction	✓(1)	1.Many established practitioners struggle to keep up with the development, and their is a need for educated users
Ismail et al., (2019)	Enhancing The Graduates' Employability and Career Development Through Building Information Modelling Intensive	✓(2)	1.The knowledge in BIM management, coordination and collaboration was also limited 2.Their existing knowledge of BIM and their skills using the software applications were quite limited,they were capable in learning expeditiously as the assignment provided them with real-world problems
Lassen et al., (2018)	Enhancing learning outcomes by introducing BIM in civil engineering studies -experiences from a university collage in Norway	✓(2)	1.BIM in an already packed curriculum for higher engineering education is also one of the barriers to educators 2.The capability to learn expeditiously as the assignment provided them with real-world problems
Maharika et al., (2020)	Building Information Modelling(BIM) Adoption Model Architectural Education	✓(3)	1.Current models of BIM adoption are directed toward the area of construction industries (consultant firms and contractors) 2.The lack of IT infrastructure; BIM resource-intensive;lack of government direction; the cost of staff lecturers training; availability of qualified staff to take BIM courses; the need to continually upgrade the BIM software; and the lack of accreditaton standards and requirements to guide the implementation of BIM within a curriculum 3.BIM in an already packed curriculum for higher engineering education is also one of the barriers to educators as the capability to learn expeditiously as the assignment provided them with real-worlds problems
Alizadehsalehi et al., (2021)	Assessment of AEC Students' Performance Using BIM-into-VR	✓(1)	The current shortage of AEC professionals trained in BIM and VR is still a barrier to collaborative working practice in this industry
Nikolic, (2021)	Teaching BIM as a collaborative information management process through a continuous improvement assessment lens: a case study	✓(1)	The adoption of BIM have been slow and inconsistant, due to, amoung other things, and overwhelming need to upskill the existing practice community in how to properly apply them on projects
Zhang et al., (2020)	Evaluation Framework for an Interdisciplinary BIM Capstone course in Highway Engineering*	✓(2)	1.Limited studies devoted to improving BIM education in highway engineering 2.The current BIM is advancements, and the lack of collaboration amoung Higher Education Institution is a barrier identified to obstruct enhanced awareness of leading BIM

Table 5b - The Barriers in Implementing BIM

Author,s	Journal Title	No of Reading Found in article	The barriers to implementing BIM in education
Aziz, (2019)	Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher institution	√(1)	The higher education institution hardly fulfilled the aspect of the management categories due to the difficulties of arranging a multidiscipline collaboration with other departments such as architecture,planning, building surveying, engineerng, and other built environment-related disciplines
Babatunde et al., (2018)	Analysis of the drivers and benefits of BIM incorporation into quantity surveying profession Academia and student,s persspectives	√(1)	The importance of industries may be the same or different from education counterparts
Casasayas et al., (2021)	Integrating BIM in Higher Education Programs: Barriers and Remedial Solutions in Australia	√(7)	1.The difficulties for educators to assess whether students are competent in certain BIM content mainly refer to vertical curriculum integration issues associated with educators 2.Majority of participants, educators lag behined Industry Practices BIM in currently going through fast-paced innovation cycles where changes 3.The efforts to establish effective BIM eduction programs would act as the driver towards identifying the top priority areas to manage the required reform 4.The problems associated with shifting from traditionally taught programs to digital visualisations and coding inherent within BIM 5.Unfavourable Professional accreditation Processes 6.Lack of Professional development Opportunities 7.Lack of Collaboration amoung HEIs
Chen et al., (2020)	University-industry collaboration for BIM education Lessons learned from a case study	√(4)	1.The universities educator helped the industry representatives identify how best their involvement could help student consolidate their BIM knowledge and support understanding professional content,the primary learning outcome 2.The difficulties in transforming existing programs, a lack of instructors with sufficient practical knowledge, and misalignment of educational outcomes and industry needs 3.Traditional in-class lectures focused heavily on theory and struggled to guarantee skill development and collaborative practice with the involvement of the industry partner allowed students to experience a real-would work environment 4.The rapidly growing demand for BIM education remains overwhelmed and stuck by varoius issues related to pedagogical design, course delivery, lack of sufficient expertise and, particularly the misalignment of educational outcomes and industry needs

Table 5b – Continued

Author,s	Journal Title	No of Reading Found in article	The barriers to implementing BIM in education
Isanovic & Colakoglu,(2020)	students' perceptions of BIM learning scenario in architectural eduaction	√(1)	1.Many established practitioners struggle to keep up with the development, and their is a need for educated users
Ismail et al., (2019)	Enhancing The Graduates' Employability and Career Development Through Building Information Modelling Intensive	√(2)	1.The knowledge in BIM management, coordination and collaboration was also limited 2.Their existing knowledge of BIM and their skills using the software applications were quite limited,they were capable in learning expeditiously as the assignment provided them with real-world problems
Lassen et al., (2018)	Enhancing learning outcomes by introducing BIM in civil engineering studies -experiences from a university collage in Norway	√(2)	1.BIM in an already packed curriculum for higher engineering education is also one of the barriers to educators 2.The capability to learn expeditiously as the assignment provided them with real-world problems
Maharika et al., (2020)	Building Information Modelling(BIM) Adoption Model Architectural Education	√(3)	1.Current models of BIM adoption are directed toward the area of construction industries (consultant firms and contractors) 2.The lack of IT infrastructure; BIM resource-intensive;lack of government direction; the cost of staff lecturers training; availability of qualified staff to take BIM courses; the need to continually upgrade the BIM software; and the lack of accreditaton standards and requirements to guide the implementation of BIM within a curriculum 3.BIM in an already packed curriculum for higher engineering education is also one of the barriers to educators as the capability to learn expeditiously as the assignment provided them with real-worlds problems
Alizadehsalehi et al., (2021)	Assessment of AEC Students' Performance Using BIM-into-VR	√(1)	The current shortage of AEC professionals trained in BIM and VR is still a barrier to collaborative working practice in this industry
Nikolic, (2021)	Teaching BIM as a collaborative information management process through a continuous improvement assessment lens: a case study	√(1)	The adoption of BIM have been slow and inconsistant, due to, amoung other things, and overwhelming need to upskill the existing practice community in how to properly apply them on projects
Zhang et al., (2020)	Evaluation Framework for an Interdisciplinary BIM Capstone course in Highway Engineering*	√(2)	1.Limited studies devoted to improving BIM education in highway engineering 2.The current BIM is advancements, and the lack of collaboration amoung Higher Education Institution is a barrier identified to obstruct enhanced awareness of leading BIM

	Mitigating strategies for implementing BIM in educational institutions			
	Curriculum integration	HEIs-industry collaboration	Education and training	New technology adoption
Alizadehsalehi et al., (2021)	Learn several software applications to deal with the interoperability issue, from a 3D/BIM-based to a VR-enabled model			
Aziz, (2019)	Providing workshops, collaboration, open-learning platforms and project-based learning strategies should be adopted to embed BIM into the curriculum		1. Equipping them with BIM technology skills, and the current BIM education level in the AEC profession falls within the infused level where the BIM knowledge	Different approaches of teaching strategies such workshop, collaboration, open-learning platform and project-based learning strategies should be adopted in embedding BIM into the curriculum
Babatunde et al., (2018)			Improve their knowledge and skills in BIM and apply BIM to their daily practices	
Casasayas et al., (2021)		Collaboration between industry and government		Accreditation bodies and professional institutions must be key players to facilitat knowledge transfer between industry and universities
Chen et al., (2020)	The order of educational activities could be adjusted more appropriately for the next iteration of BIM education	1. The university recognised the industry's needs and the degree of practical knowledge necessary regarding BIM implementation 2. BIM educators need to maintain regular and effective bi-directional communication with the industry		
Commons & Ozcan Deniz, (2018)	The need to embrace both CAD and BIM in the AEC curriculum by following the results and guidelines presented in this study to develop CAD/BIM courses			Acquired and improved their technical skills using Autodesk Revit, AutoCAD, Naviswork Manage and Microsoft Project, which benefit their employment
Dan et al., (2023)	BIM should be implemented considerably			
Isanović & Çolakoğlu, (2020)		Promote self-learning and a study-centred approach, which are critical requirements of 21st-century curricula		

Table 5c - Strategies to Mitigate Barriers

	Mitigating strategies for implementing BIM in educational institutions			
	Curriculum integration	HEIs-industry collaboration	Education and training	New technology adoption
Ismail et al., (2019)	1. Integrate BIM education into the HEIs curricula in Malaysia is that industry involvement in the training helps establish a good relationship between industry 2. HE institution, subsequently opening the opportunity for an internship programme in BIM-based projects in the future	1. Collaboration between professionals and the HEIs sector 2. Collaboration between the industrial practitioners and HE institutions need be done more vigorously to help academicians in guiding the students and providing access to BIM-based project information		
Lassen et al., (2018)	1. BIM-based curricula should be developed where construction knowledge is fused into these curricula 2. Alternative ways to include BIM in the curriculum while at the same time strengthening – rather than supplanting - the traditional engineering subjects			
Maharika et al., (2020)	The criteria of the curriculum must also involve the process of integration		Prepared and provide availability of schemes to strengthen their competencies in skills	1. The change toward innovation and multidisciplinary and interprofessional support for collaboration 2. Develop a vision, strategy and roadmap for the integration of BIM in the academic environment as soon as possible as the gap is widening between education and the demand of AEC industry 3. Develop a multidisciplinary community in operation, technical and nontechnical solutions, and research, and the readiness of this infrastructure will be closely related to the readiness of trained staff in the organisation

Table 5c - Continued

	Mitigating strategies for implementing BIM in educational institutions			
	Curriculum integration	HEIs-industry collaboration	Education and training	New technology adoption
				4. Technology and infrastructure, the readiness of skilled trainers or human resources, and knowledge organisation that support the entire process ranging from the preparation, learning process, evaluation, and decision
Nikolic, (2021)				Managing the technology aspect meant understanding access to resources, file storage capacity and technology appropriateness for the given tasks. Some of these challenges were evident in choosing between Solibri and NavisWorks
Zhang et al., (2020)			1. Needs to be combined with opportunities for practical application besides the training 2. Adding BIM construction technology and BIM operation and maintenance management to the capstone to enrich the complete cycle management of BIM	

Table 5c - Continued

Conclusion

BIM is a digital presentation platform that allows the exchange of information, integration and detection of conflict in projects (Eastman, C., Teicholz, P. Sacks, 2018). BIM is also a proven core technology in the construction industry (Sepasgozar et al., 2021). Although BIM has diffe - ent definitions and interpretations depending on particular users' points of view, the facts remain as a digital model full of technologies involved. Construction projects have crucially changed after utilising intelligent technologies and tools in the AEC industry (Rafsanjani & Nabizadeh, 2021). Thus, to satisfy the AEC industry requirements, many UK universities have started integrating the concepts into AEC education (Abbas et al., 2016). Considerable progress has been made in incorporating BIM into AEC curricula, particularly in developed countries such as the USA, the UK, Australia, New Zealand, Hong Kong and Singapore (Babatunde et al., 2018). While Hu (2019) found that integrating BIM into a teaching technology platform will also provide a novel pedagogical approach and give more positive evidence of its effecti eness than in traditional courses in an architecture curriculum. Barriers to implementing BIM education in the higher educa tion system as the barriers to incorporating BIM into the curriculum in higher education institutions (Cruywagen & Llale, 2017). In the process, the integrated design approach was embedded. It showed a strong link between academic activities and real-world industrial practice, including the interoperability of building information exchange among different digital platforms (Jin et al., 2018). It shows the need to implement BIM in higher education institutions, as supported by students and teachers. However, there is no analysis of the Malaysian TVET institutions, except in some cases, implementation of BIM carried out in other Malaysian Higher Education Institutions. In contrast, the TVET institutions also need to strengthen and reform the meaningful way of producing a quality and skillful workforce in the nations (Talent Corporation Malaysia Berhad, 2020). Consequently, numerous research studies on BIM in Malaysia have been available recently, easily accessible from search engines. This is related to the increase in awareness of BIM implementations in Malaysia and the initiatives provided by the government. However, most studies only focus on BIM from an industrial perspective, such as implementation, adoption, and technology application derived from industry professionals, government and AEC players, with a few papers focusing on BIM in educational institutions obtained

from those educators and students. The industry perspective of BIM is often focused on the current industry demands with minimal or no involvement with educational institutions. The need to study specific issues in BIM implementation among educators in TVET institutions and coordination with industry professionals is necessary to unveil the present status of BIM in each of the professions. The Malaysian TVET Institutions are responding to these barriers by implementing BIM the institute to curriculum design, collaboration extending to multiple professionals in the industries at the same time, and providing adequate education and training to their educators, which sets out the relationships between curriculum and the digitalisation of the construction industry and also readily adopting the new technologies that demanded by the industry from the elementary introduction of BIM to more advanced conceptual teaching in a virtual BIM environment This paper has attainable a systematic literature review of The Awareness of Implementing Building Information Modelling (BIM) for Educators in Malaysia TVET Institutions; with the understanding of BIM awareness and the barriers in implementing BIM to the institutions, the strategies for mitigating barriers to implementing BIM were obtained from this study. Like other systematic literature reviews, this study may be limited by the specific search keywords and the chosen bibliographic databases. To complete this study and, as a future line of research, future studies need to be geared toward BIM implementation in TVET institutions, a reflection on coordination between institutions is necessary to provide institutions with the necessary standards for individuals, which can strengthen transversally between subjects when carrying out BIM implementation in their curriculum. Also, the perceived barriers and benefits of implementing BIM differ from other institutions. Therefore, it is necessary to develop scientific literature in which researchers from different professions can cooperate in search of standard solutions. This can assist the institutions and educators in understanding and determining suitable approaches for designing curricula and conceptualising frameworks in implementing BIM.

Acknowledgements
The author would like to thank Universiti Sains Malaysia for their continuous support of this study.

Conflict of interest
The authors declare no conflict of interest involved in the study.

References
[1] Ademci, E., & Gundes, S. (2018). Review of Studies on BIM Adoption in AEC Industry. https://ssrn.com/abstract=3615107
[2] Agirbas, A. (2020). Teaching construction sciences with the integration of BIM to undergraduate architecture students. Frontiers of Architectural Research, 9(4), 940–950. https://doi.org/10.1016/j.foar.2020.03.007
[3] Alizadehsalehi, S., Hadavi, A., & Huang, J. C. (2021). Assessment of AEC students' performance using BIM-into-VR. Applied Sciences (Switzerland), 11(7). https://doi.org/10.3390/app11073225
[4] Ang Soon Ern, P., Xian Yang, W., Kasim, N., Hairi Osman, M., Hani Adnan, S., Suhada Natasha, N., & Ali, R. (2022). Building Information Modelling (BIM) in Malaysian Industrialised Building System (IBS) Construction Projects: Benefits and Challenges. IOP Conference Series: Earth and Environmental Science, 1022(1). https://doi.org/10.1088/1755-1315/1022/1/012020
[5] Aziz, N. M. , Y. P. X. b , Z. N. (2019). Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution. In International Journal of Innovation, Creativity and Change. www.ijicc.net (Vol. 9, Issue 7). www.ijicc.net
[6] Babatunde, S. O., Ekundayo, D., Babalola, O., & Jimoh, J. A. (2018a). Analysis of the drivers and benefits of BIM incorporation into quantity surveying profession: Academia and students' perspectives. Journal of Engineering, Design and Technology, 16(5), 750–766. https://doi.org/10.1108/JEDT-04-2018-0058
[7] Babatunde, S. O., Ekundayo, D., Babalola, O., & Jimoh, J. A. (2018b). Analysis of the drivers and benefits of BIM incorporation into quantity surveying profession: Academia and students' perspectives. Journal of Engineering, Design and Technology, 16(5). https://doi.org/10.1108/JEDT-04-2018-0058
[8] B. Kitchenham and S. Charters. (2007). Guidelines for performing systematic literature reviews in software engineering. Technical Re

port, Ver. 2.3 EBSE Technical Report. EBSE, 1.
[9] Bughio, M., Khan, M. S., Mahar, W. A., & Schuetze, T. (2021). Impact of passive energy efficiency measures on cooling energy demand in an architectural campus building in karachi, pakistan. Sustainability (Switzerland), 13(13). https://doi.org/10.3390/su13137251
[10] Casasayas, O., Hosseini, M. R., Edwards, D. J., Shuchi, S., & Chowdhury, M. (2021). Integrating BIM in Higher Education Programs: Barriers and Remedial Solutions in Australia. Journal of Architectural Engineering, 27(1). https://doi.org/10.1061/(asce)ae.1943-5568.0000444
[11] Chen, K., Lu, W., & Wang, J. (2020). University–industry collaboration for BIM education: Lessons learned from a case study. Industry and Higher Education, 34(6), 401–409. https://doi.org/10.1177/0950422220908799
[12] Commons, J. D., & Ozcan Deniz, G. (2018). Emerging cad and bim trends in the aec education: An analysis from students' perspective. https://jdc.jefferson.edu/jcabefp/
[13] Dan, W., Ismail, R., Yen, T. J., Jing, K. T., Zhangfei, K., Yunbo, Z., Wira, M., Shafiei, M., & Yee, H. C. (2023). Digital Technology Fluency and BIM Learning Environment in Undergraduate Construction Management. 13(1).
[14] Eastman, C., Teicholz, P. Sacks, R. and G. L. (2018). BIM Handbook - A Guide to Building Information Modelling for Owners, Designers, Engineers, Contractors, and Facility Managers. In Wiley and Sons.
[15] Hedayati, A., Mohandes, S. R., & Preece, C. (2015). Studying the Obstacles to Implementing BIM in Educational System and Making Some Recommendations. J. Basic. Appl. Sci. Res, 5(3).
[16] Institut Maklumat & Analisis Pasaran Buruh (ILMIA). (2018). Technical and Vocational Education and Training Final Report.
[17] Isanović, H., & Çolakoğlu, B. (2020). Students' perceptions of bim learning scenario in architectural education. A/Z ITU Journal of the Faculty of Architecture, 17(3), 195–209. https://doi.org/10.5505/itujfa.2020.87528
[18] Ismail, A. S., Ali, K. N., Mustaffa, N. E., A. Iahad, N., & Yusuf, B. Y. (2019). ENHANCING THE GRADUATES' EMPLOYABILITY AND CAREER DEVELOPMENT THROUGH BUILDING INFORMATION MODELLING INTENSIVE TRAINING. International Journal of Built Environment and Sustainability, 6(1–2), 91–99. https://doi.org/10.11113/ijbes.v6.n1-2.387
[19] Kamaruzzaman, S. N., Suznan, S. N., & Myeda, N. E. (2023). Building information modelling facilities management (BIM-FM) coordination for digital construction project. Journal of Facilities Management. https://doi.org/10.1108/JFM-10-2021-0127
[20] Lame, G. (2019). Systematic literature reviews: An introduction. Proceedings of the International Conference on Engineering Design, ICED, 2019-August, 1633–1642. https://doi.org/10.1017/dsi.2019.169
[21] Lassen, A. K., Hjelseth, E., & Tollnes, T. (2018). Enhancing learning outcomes by introducing bim in civil engineering studies – experiences from a university college in Norway. International Journal of Sustainable Development and Planning, 13(1), 62–72. https://doi.org/10.2495/SDP-V13-N1-62-72
[22] Maglad, A. M., Houda, M., Alrowais, R., Khan, A. M., Jameel, M., Rehman, S. K. U., Khan, H., Javed, M. F., & Rehman, M. F. (2023). Bim-based energy analysis and optimization using insight 360 (case study). Case Studies in Construction Materials, 18. https://doi.org/10.1016/j.cscm.2022.e01755
[23] Maharika, I. F., Irsan, A., Al Athas, S. I., Susanto, A., Abma, V., & Yuriandala, Y. (2020). Building information modelling (BIM) adoption model for architectural education. Journal of Design and Built Environment, 20(3), 22–42. https://doi.org/10.22452/jdbe.vol20no3.2
[24] Puolitaival, T., & Forsythe, P. (2016). Practical challenges of BIM education. Structural Survey, 34(4–5). https://doi.org/10.1108/SS-12-2015-0053
[25] Rafsanjani, H. N., & Nabizadeh, A. H. (2021). Towards digital architecture, engineering, and construction (AEC) industry through virtual design and construction (VDC) and digital twin. Energy and Built Environment. https://doi.org/10.1016/j.enbenv.2021.10.004
[26] Robinson, P., & Lowe, J. (2015). Literature reviews vs systematic reviews. In Australian and New Zealand Journal of Public Health (Vol. 39, Issue 2). https://doi.org/10.1111/1753-6405.12393
[27] Shaffril, H. A. M., Samah, A. A., & Kamarudin, S. (2021). Speaking of the devil: a systematic literature review on community preparedness for

earthquakes. In Natural Hazards (Vol. 108, Issue 3). https://doi.org/10.1007/s11069-021-04797-4
[28] Sinoh, S. S., Ibrahim, Z., Othman, F., & Muhammad, N. L. N. (2020). Review of BIM literature and government initiatives to promote BIM in Malaysia. IOP Conference Series: Materials Science and Engineering, 943(1). https://doi.org/10.1088/1757-899X/943/1/012057
[29] Talent Corporation Malaysia Berhad. (2020). TalentCorp_Annual Review 2019_FINAL. Talent Corp Annual Review 2019.
[30] Um, J., Park, J. min, Park, S. yeon, & Yilmaz, G. (2023). Low-cost mobile augmented reality service for building information modeling. Automation in Construction, 146. https://doi.org/10.1016/j.autcon.2022.10466
[31] Valinejadshoubi, M., Moselhi, O., & Bagchi, A. (2022). Integrating BIM into sensor-based facilities management operations. Journal of Facilities Management, 20(3), 385–400. https://doi.org/10.1108/JFM-08-2020-005
[32] Yilei Huang. (2018). A Review of Approaches and Challenges of BIM Education in Construction Management. Journal of Civil Engineering and Architecture, 12(6). https://doi.org/10.17265/1934-7359/2018.06.001
[33] Yusoff, R. M., Harun, A., & Zakaria, A. M. (2020). 52 TVET in Malaysia: Capabilities and Challenges as Viable Pathway and Educational Attainment. In Journal on Technical (Vol. 5, Issue 1). http://upikpolimas.edu.my/ojs/
[34] Yusoff, S. N. S., Brahim, J., & Mat Yusoff, Z. (2021). Incorporation of Building Information Modelling (BIM) in Malaysian Higher Education Institutions: A Review. Built Environment Journal, 18(1). https://doi.org/10.24191/bej.v18i1.10404
[35] Zhang, J., Zhao, C., Wang, J., Li, H., & Huijser, H. (2020). Evaluation Framework for an Interdisciplinary BIM Capstone course in Highway Engineering*.
[36] Zima, K., Plebankiewicz, E., & Wieczorek, D. (2020). A SWOT analysis of the use of BIM technology in the polish construction industry. Buildings, 10(1). https://doi.org/10.3390/buildings10010016

Recieved: May-02-2023 Revised: Aug-20-2023 Accepted: October-20-2023