IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 12(3)/2025, 49-64

Next-Generation BIM Competency: Curriculum Integration to Equip UTM Civil Engineering Graduates for Industry Demands

Ng Hock Seng
Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor.

Ng Chiew Teng, Suzila Mohd & Mohamad Shazwan Ahmad Shah
Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor.

Ng Teck Wei
Department of Construction Management, Faculty of Built Environment, Tunku Abdul Rahman University Management and Technology, Setapak, 53300 Kuala Lumpur.

Tie Mei Sin
Jurutera Minsar Consult Sdn Bhd, Level 2 & 3, Westmoore House, Twin Tower Center, Rock Road, 93200 Kuching, Sarawak

ABSTRACT

Building Information Modelling has modernized the landscape of construction management and education by presenting innovative resources that enrich the teaching and application of industry-specific management practices. However, there remains a lack of standardised criteria for cultivating skilled BIM graduates and proving that current course information meets the construction industry's demands for fresh graduates. This study aims to integrate BIM into the civil engineering curriculum at Universiti Teknologi Malaysia (UTM) to better equip undergraduates with the competencies required by the Malaysian construction industry. Using a mixed-method explanatory sequential design, the study focuses on quantitative data collection and analysis, then transitions to qualitative methods to validate the initial findings and provide further insights. Data was collected from 90 civil engineering students at UTM who had completed BIM courses, with a response rate of 48.65%. The findings indicate that the current curriculum does not fully prepare graduates with the essential BIM skills required in the workplace, as BIM adoption in Malaysia is largely confined to 3D applications. The study identifies key technical skills for BIM-proficient graduates, such as modelling, information management, project coordination and interoperability with BIM tools. While non-technical skills go to adaptability and flexibility, continuous learning, collaboration and visualisation. To enhance the curriculum, it is recommended to provide elective courses in BIM, continuous curriculum updates, soft skills developments and hands-on experience. A BIM conceptual framework for integration into the UTM curriculum is proposed based on data collected from surveys, expert consultations, and an extensive literature review. The study presents valuable insights into the current state of BIM education at UTM and can be a point of reference for future research on standardising BIM teaching protocols in Higher Education Institutions (HEIs).

Article History

Received: *22 October 2024*
Received in revised form: *18 March 2025*
Accepted: *29 April 2025*
Published Online: *01 September 2025*

Keywords:

Building Information Modelling, conceptual framework, civil engineering curriculum, improvements, UTM

Corresponding Author Contact:

chiewteng.ng@utm.my

DOI: 10.11113/ijbes. v12.n3.1454

1. Introduction

For decades, the construction industry has lagged in terms of digital integration (CIDB, 2022). However, advancements in Building Information Modelling (BIM) have revolutionised project management by enhancing collaboration and information sharing (Del Savio et al., 2022). Given the industry's complexity and fragmentation, embracing advanced technologies like BIM is considered essential for progress in today's era. BIM is a transformational approach that improves communication and cooperation between project stakeholders while using digitalisation to manage project information throughout the construction life cycle (Ahankoob et al., 2022). In Malaysia, the latest Construction 4.0 Strategic Plan (2021-2025) aims to promote the adoption of BIM alongside 11 other emerging technologies to enhance productivity in the construction industry (CIDB, 2020). Despite this, BIM adoption remains at 55% as of 2021 (CIDB, 2022; Seng et al., 2025), indicating that further implementation is required to fully integrate BIM into the construction industry.

Higher education institutions (HEIs) play a crucial role in addressing this gap by equipping graduates with BIM competencies. Industry stakeholders, including the Malaysian Public Works Department (PWD) and Construction Industry Development Board (CIDB), have collaborated with universities through Memoranda of Understanding (MoUs) to enhance BIM education (Jiang, 2021). While research acknowledges the growing importance of BIM in civil engineering curricula (Sampaio, 2022), previous studies highlight a lack of standardised measures for developing proficient fresh graduates to meet the construction industry's demands (Guo et al., 2023). Fresh graduates entering the construction industry will face strong competition from experienced BIM specialists because most companies prioritise candidates with basic BIM skills. The skills are divided into two categories, which are technical skills with BIM tools and multi-trade coordination, and non-technical skills with communication skills and collaboration (Le et al., 2018). In Malaysia, BIM-related roles such as BIM manager, BIM coordinator and BIM specialist are increasingly emerging (Ng and Aryani, 2022).

Brahim et al. (2021) emphasised the need for better BIM adoption in Malaysian higher education by evaluating the current syllabus among HEIs. Due to limitations in resources, awareness and the level of BIM knowledge among academics, universities have struggled to implement BIM education at the tertiary level. As a premier Malaysian university in engineering education, Universiti Teknologi Malaysia (UTM) is well-positioned to bridge this gap. UTM has existing BIM-related courses within its civil engineering curriculum and has actively expanded its BIM education by introducing dedicated Master's courses in recent years. Besides, UTM regularly collaborates with industry partners to provide BIM seminars for students to ensure that graduates are exposed to industry practices and emerging trends. Therefore, UTM is a suitable case study for assessing BIM curriculum integration and its alignment with industry demands.

In summary, this study aims to assess the effectiveness of BIM courses at UTM and propose curricular enhancement to align with industry demand. The objectives of this study are (1) to identify the readiness of existing BIM courses in producing BIM-proficient graduates, (2) to assess the key criteria for BIM proficiency within the Malaysian construction industry, and (3) to validate the integration of BIM into the UTM curriculum in preparing BIM-proficient graduates.

1.1 BIM in Undergraduates Curricular Programs of Civil Engineering

Wang et al. (2020) highlighted the importance of integrating individual BIM courses into the curricula of Architecture, Engineering and Construction (AEC) programs. To evaluate BIM integration in Malaysian undergraduate civil engineering programs, five research universities in Malaysia which are University Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM) and Universiti Teknologi Malaysia (UTM), have been selected to investigate the integration of BIM-related courses within their civil engineering programs. However, USM does not currently offer a BIM course in its civil engineering program.

According to the published circular program guidelines from each university's Faculty of Civil Engineering, UKM offers three BIM-related courses for undergraduate students. The first year focuses on Construction Management with BIM, while the fourth year delves into BIM in Geospatial Analytics and BIM in Industrialised Building Systems (IBS). Other universities usually include only one BIM-related course in the third year of their civil engineering programs. However, UTM slightly deviates by giving 2 credit hours to its BIM course, which is less than the 3 credit hours given by other universities. Furthermore, while BIM is part of the elective subjects at UTM for civil engineering, it is not open for students to take currently. Table 1 outlines the BIM-related courses offered at five research universities in Malaysia.

Table 1 BIM courses in Malaysian research universities

University	Course Code (Course Name)	Year/ Credit Hours	Course Information
Universiti Malaya (UM)	KIA3015 (Construction Management and Technology)	3/3	This course covers the management of development, change, and innovation in operational works, with a focus on activities such as overall planning, synchronization, and supervision of construction projects from beginning to end.
Universiti Kebangsaan Malaysia (UKM)	KKCE1213 (Civil Engineering Graphics And Building Information Modelling)	1/3	The course covers theoretical and practical aspects of civil engineering drawings, incorporating the use of CAD tools, and will concentrate on enhancing skills in generating, overseeing, and tailoring BIM models.
	KKCE4333 (Geospatial Analysis)	4/3	The course covers spatial analysis techniques, including satellite imagery, UAV, LiDAR, 3D modelling, BIM, and forecasting models.
	KKCE4423 (Design of Industrialized Building System)	4/3	The course covers the Industrial Building System (IBS), its benefits, components, comparison with conventional methods, and BIM solutions in IBS.
Universiti Putra Malaysia (UPM)	ECV3723 (Building Information Modelling for Engineers)	3/3	The course covers BIM concepts, applications, and innovative construction methods, with a focus on enhancing computer skills related to BIM.
Universiti Teknologi Malaysia (UTM)	SEAA3412 (Building Information Modelling and Data Management)	3/2	The course covers practical experience in BIM and data management, giving the students the ability to plan, analyze, and develop BIM models for civil engineering problems.
	SEAA4423 (Building Information Modelling)	4/3	Not offered

Source: (UKM, 2022; UM, 2023; UPM, 2021; UTM, 2022)

2. Methodology

2.1 Description of Research Approach

A mixed method approach was adopted in this study as it allows for a more comprehensive analysis of BIM curriculum integration. This approach aligns with previous studies in BIM education research (Casasayas et al., 2021; Yusuf et al., 2017). The quantitative approach (via surveys) was employed to address research objectives 1 and 2 by identifying BIM course readiness and assessing key criteria, while the qualitative approach (via semi-structured interviews) was used to address research objective 3 by validating the integration of BIM into the curriculum. Figure 1 shows the research flowchart of the study.

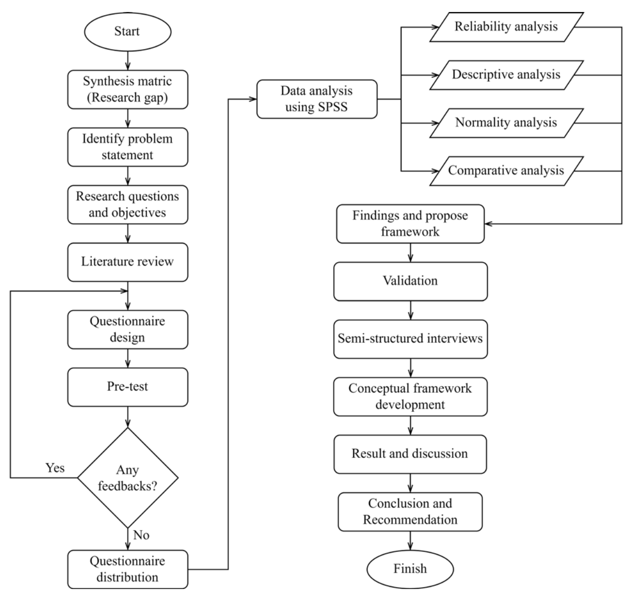


Figure 1 Study flowchart

2.2 Quantitative Approach

The quantitative approach involves distributing questionnaires for respondents to provide their ratings. The questionnaire is divided into several sections, which are Section A: Demographic Profile; Section B: The readiness of existing BIM courses in producing BIM-proficient graduates; Section C: BIM-proficient key criteria from the Malaysian construction industry; and Section D: The integration of BIM and UTM curriculum in producing BIM-proficient graduates. A six-point Likert scale was adopted for the survey to enhance measurement precision (Taherdoost, 2019). The scale ranged from 1 (extremely low) to 6 (extremely high), with the intermediate points being very low (2), low (3), high (4) and very high (5). The selection of a six-point Likert scale is to avoid a neutral midpoint, thus encouraging respondents to make a positive or negative response (Kusmaryono et al., 2022).

The target population for this study is UTM civil engineering undergraduate students and graduates from civil engineering who are employed. According to Chaokromthong and Sintao (2021), Yamane's formula was suitable for survey studies and finite populations, as shown in equation (1).

$$Sample\ size, n = \frac{N}{1 + Ne^2} \qquad (1)$$

where *N* represents population size, and *e* represents margin error. Due to resource limitations, the population size was estimated in Table 2 using graduation lists from 2022 and 2023, and the current number of active third year and fourth year students who have completed BIM courses. With 95% confidence intervals and 5% margin of error (e), the sample size (*n*) obtained is 185.

Table 2 Population size

Graduates from the graduation list	334 (Year 2022) 454 (Year 2023)
Number of existing students	300 (Year 3) 290 (Year 4)
Average (*N*)	345

A pre-test was conducted with 10 fourth-year UTM civil engineering students who had completed BIM courses in their third year. The questionnaire was revised based on their feedback, which included several suggestions, such as capitalising the title for each section, bolding the instructions for the respondents and reviewing all grammatical errors in the questions for Section C.

2.3 Quantitative Analysis

Three analyses were conducted using SPSS, such as reliability analysis, descriptive analysis and comparative analysis. The reliability test was performed to determine the Cronbach's alpha value, with a value greater than 0.70 indicating that the questions were acceptable for further analysis (Taber, 2018). Descriptive analysis included calculating the mean, standard deviation and Relative Importance Index (RII). The mean and standard deviation were obtained in SPSS, while the RII values were manually calculated using Microsoft Excel. The RII formula has been widely applied in previous construction management and educational studies (Azman et al., 2019; Jin et al., 2019; lot Tanko and Mbugua, 2022), as it allows for the ranking of factors in a systematic and quantitative manner. The RII formula is provided in equation (2).

$$RII = \frac{n_{EL} + 2n_{VL} + 3n_L + 4n_H + 5n_{VH} + 6n_{EH}}{AN} \qquad (2)$$

where n_{EL} represents the number of respondents selecting "extremely low", n_{EH} represents the number of respondents selecting "extremely high", *A* is the highest scale, and *N* is the total sample size.

Furthermore, a comparative analysis between two independent groups (graduates and students) was conducted, focusing on their mean, standard deviation, and ranking. The Kolmogorov-Smirnov test was employed to assess the normality of distribution for each variable. If the data followed a normal distribution, a parametric test, such as the t-test, was conducted; otherwise, a non-parametric test, such as the Mann-Whitney U test, was utilised. In this study, due to the non-normal distribution of data (Kolmogorov-Smirnov test, $p < 0.05$), the Mann-Whitney U test was employed to compare independent groups. These tests aimed to assess the significant differences between graduates and students regarding the readiness of existing courses, technical skills, non-technical skills and curriculum improvements.

2.4 Qualitative Approach

Semi-structured interviews were employed in this study to gather qualitative data. To validate the BIM-related course suggestions, semi-structured interviews were conducted with BIM specialists and instructors from both the public and private sectors. This method was supported by similar studies (Alaloul et al., 2023; Del Savio et al., 2022). During these interview sessions, interviewees were encouraged to provide additional information as new questions emerged throughout the discussion. Five interviewees from BIM experts or instructors were invited to give feedback on the findings and discuss the BIM implementation in the curriculum in more detail. This number of interviewees aligns with previous construction management studies that use a qualitative approach (Arroteia et al., 2021; Aziz and Zainon, 2023).

2.5 Qualitative Analysis

The interview transcripts were summarised. Amendments were made when at least three out of the five interviewees agreed. The ranking refinement for each objective was based on the findings of the qualitative analysis.

3. Result and Discussion

After a designated period from questionnaire distribution, the responses were collected and screened for completeness and relevance. A stratified sampling approach was applied, with 45 responses collected from UTM students first. To ensure balanced representation, an additional 45 responses were then collected from UTM graduates. The response rate is 48.65% based on the sample size of 185 students. Wu et al. (2022)

concluded that the average response rate for online surveys in education-related fields is 44.1%. Therefore, the response rate in this study exceeds the average response rate and is considered acceptable.

3.1 Reliability Analysis

A reliability analysis was performed on all sections of the questionnaire to evaluate the internal consistency of the responses, as presented in Table 3. Cronbach's alpha values greater than 0.7 indicate acceptable reliability, while values less than 0.7 represent poor internal consistency and require revisions to the items. In this study, no additional revisions were necessary as all Cronbach's alpha values were above 0.8.

Table 3 Reliability analysis

Section	Cronbach's alpha	No of Items
B	0.880	10
C	0.957	14
D	0.949	10
Overall	0.964	34

3.2 Descriptive Analysis

This section presents the findings of the descriptive analysis for each objective. It is important to note that only the top five ranked technical skills, non-technical skills and suggestions of BIM integration in the UTM curriculum were used to develop the conceptual framework in this study. However, these items require further validation by industry experts, and adjustments in ranking may be made if a consensus is reached.

3.2.1 RO1: The Readiness of Existing BIM Courses

Table 4 summarises the findings from Section B of the questionnaire, which assesses the readiness of existing BIM courses to produce BIM-proficient graduates. An impressive 95.6% agreed that integrating BIM courses in higher education would significantly enhance BIM adoption in Malaysia's construction industry. Similarly, strong agreement (95.6%) existed on the importance of mastering BIM for civil engineers. Additionally, 80% found that working with BIM software easy, while 91.2% expressed willingness to continue learning BIM in the future. These positive responses highlight both a clear understanding of BIM's importance and a strong acceptance of BIM education within the civil engineering curriculum at UTM.

Table 4 Readiness of existing BIM courses

Label	Statements	"Extremely Low" to "Low" (Disagree)	"High" to "Extremely High" (Agree)
A1	To what extent do you believe that integrating BIM courses in Higher Education Institutions can enhance BIM adoption in the Malaysian construction industry?	4.4%	95.6%
A2	To what extent do you believe that mastering BIM is a crucial skill for civil engineers?	4.4%	95.6%
A3	To what extent do you find working with BIM software easy?	20%	80%
A4	To what extent do you believe that the topics lectured were up to date with the latest industry trends?	27.8%	72.2%
A5	To what extent do you believe that knowledge about BIM can provide better job opportunities?	7.7%	92.3%
A6	How would you rate your knowledge of BIM before attending BIM-related courses?	65.5%	34.5%
A7	How would you rate your knowledge of BIM after attending BIM-related courses?	16.7%	83.3%
A8	How would you rate your application of BIM knowledge in assignments, projects, or competitions?	24.4%	75.6%
A9	How would you rate your willingness to continue learning BIM in the future?	8.8%	91.2%
A10	How would you rate your satisfaction level with the BIM-related course provided at UTM?	25.5%	74.5%

3.2.2 RO2: Technical Skills

Table 5 outlines seven statements related to technical skills, and the results show that the most important technical skills were modelling skills, information management and interoperability.

The most important technical skill was identified as modelling skill (B3), as evidenced by the requirements for UTM civil engineering students to take the course "SEAA 1422 Engineering Drawing" as a prerequisite for "SEAA 3412 Building Information Modelling and Data Management" (UTM, 2022). In addition, interoperability skills (B1) were essential for allowing users to exchange data efficiently across different BIM tools and software platforms to achieve optimal outcomes. Project coordination (B4) and quantification and estimation (B6), which are typically involved in 4D and 5D BIM processes, were ranked lower in importance. Furthermore, the lack of appropriate BIM guidelines (B2) for organisations and policymakers was identified as a challenge in BIM implementation within the construction industry (Al-Ashmori et al., 2022; Syafika et al., 2022). Lastly, parametric modelling (B7) was ranked the lowest as it contributes to a high level of detail (LOD) and enables automatic updates in models when a parameter is changed (Mehranfar et al., 2024).

Table 5 Ranking of technical skills

Label	Statements	Mean	Std. deviation	RII	Ranking
B3	Modelling skills: Ability to manipulate, navigate and review 3D models.	4.80	1.083	0.800	1
B5	Information management: Organising, managing and extracting relevant data from BIM models.	4.73	1.026	0.789	2
B1	Interoperability: Exchange data in different software.	4.61	1.078	0.769	3
B4	Project coordination: Resolve conflicts by using BIM.	4.56	1.040	0.759	4
B6	Quantification and estimation: Quantity take-off in using BIM.	4.52	1.124	0.754	5
B2	Regulatory compliance: Guidelines and standards of BIM.	4.52	1.173	0.754	6
B7	Parametric modelling: Ability to create parametric models that allow for dynamic changes.	4.51	1.134	0.752	7

3.2.2 RO2: Non-technical Skills

Table 6 outlines seven statements related to non-technical skills, and the results show that the most important non-technical skills were adaptability and flexibility, continuous learning and development, and visualisation and presentation.

Silva et al. (2021) stated that cultural resistance, technical difficulties and interoperability problems were caused by professionals lacking BIM knowledge and experience, which can hinder both BIM implementation and its benefits. Resistance to change from users who prefer traditional methods is a common obstacle to the widespread adoption of BIM. Therefore, adaptability and flexibility (B14) were ranked as top priorities among non-technical skills. Next, willingness to engage in continuous learning and development (B11) in the BIM field was identified as the second most important non-technical skill. Wang et al. (2020) suggested continuous educational innovation is necessary to connect higher education with the technical and managerial digital skills required by industries. Besides, it is well-known that mastering BIM requires a substantial amount of time and effort, as it is a complex skill set that needs dedication and consistent practice to be used effectively. Visualisation and presentation (B9) were ranked third on non-technical skills because BIM is used to transform 2D construction drawings into 3D models, which assist in communication of design concepts and simulation of construction progress. BIM is a powerful tool for communicating with clients in the AEC industry, as BIM allows clients to visualise and understand the proposed design more effectively than traditional 2D drawings (Hadavi and Alizadehsalehi, 2024). In addition, collaboration among project stakeholders (B8) is another key aspect of BIM as it provides a common platform for sharing and managing information (Raja Mohd Noor et al., 2023). The use of BIM results in centralised data management, updates that occur in real time and the ability to collaborate from anywhere. Tools like BIM 360, a cloud-based server that allows team members to interact instantly within project models, eliminating the need for traditional face-to-face coordination and the use of traditional means like email and phone calls (Onungwa et al., 2021). However, it should be noted that BIM 360 is not currently included in the BIM course syllabus at UTM, which is why it did not rank among the top three non-technical skills. Similarly, the last three non-technical skills (B13, B12 and B10) were not emphasised in the course contents.

Table 6 Ranking of non-technical skills

Label	Statements	Mean	Std. deviation	RII	Ranking
B14	Adaptability and flexibility: Ability to adapt to changes in project requirements, technology advancements and industry trends.	4.80	1.083	0.819	1
B11	Continuous learning and development: Commitment to ongoing training and professional development in BIM methodologies.	4.73	1.026	0.813	2
B9	Visualisation and presentation: Ability to generate high-quality visualisations, renderings and walkthroughs from BIM models.	4.61	1.078	0.789	3
B8	Collaborative working: Capability to collaborate effectively with multidisciplinary teams by sharing the BIM model.	4.56	1.040	0.783	4
B13	Leadership and team management: Leadership qualities lead BIM implementation.	4.52	1.124	0.780	5
B12	Quality assurance/quality control: Commitment to implementing QA/QC processes within BIM projects.	4.52	1.173	0.780	6
B10	Lifecycle management: Understanding of how BIM can be utilised beyond the design and construction phases.	4.51	1.134	0.769	7

3.2.3 RO3: BIM integration in the UTM curriculum

Table 7 outlines ten suggestions that were provided in the survey based on the literature review and potential improvements based on the current curriculum in UTM.

Based on initial expectations, the top three improvements were anticipated to be ranked in the order of continuous curriculum updates, offering BIM-related elective courses, and hands-on experience (Tsai et al., 2019). However, the results from the questionnaire showed a slightly different ranking which began with continuous curriculum updates, soft skills development, hands-on experience, and offering BIM-related elective courses. Employers increasingly value attributes such as communication, teamwork, leadership, and problem-solving skills alongside technical proficiency. These soft skills are also emphasised in the Program Learning Outcomes (PLO) listed in the course information at UTM. As a result, students recognise that developing these skills is crucial for becoming competitive candidates after graduation. Continuous curriculum updates (C6) were ranked as the top suggestion, as UTM conducts annual module reviews and program curriculum reviews at least once every 2-4 years. Currently, “SEAA 4423 Building Information Modelling” is the only BIM-related elective course in the Civil Engineering curriculum, but it has not been offered since semester one of the 2023/2024 academic year. This may explain why students are less aware of the importance of BIM elective courses for developing their expertise with BIM tools. Other options, such as professional development opportunities (C8), industry partnership (C4), interdisciplinary collaboration (C3), certification programs (C5), and research and development (C7) which involve external parties such as certified instructors or industries were ranked as less effective for integrating BIM into civil engineering curriculum. Lastly, incorporating BIM courses (C1) was ranked lowest due to issues in delivering the information, leading to misunderstanding and uncertainty about the course content (Belayutham et al., 2018).

Table 7 Ranking for improvements for BIM integration in the UTM curriculum

Label	Statements	Mean	Std. deviation	RII	Ranking
C6	Continuous curriculum updates: Keep the BIM curriculum up to date with the latest industry trends, standards, and technological advancements.	5.04	1.141	0.841	1
C10	Soft skills development: Emphasis on the development of soft skills such as communication, teamwork, problem-solving, and leadership alongside technical BIM competencies.	5.02	0.994	0.837	2
C2	Hands-on experience: Work on real-world projects and case studies.	4.97	1.156	0.828	3

C9	Offering BIM-related elective courses.	4.96	1.027	0.826	4
C8	Professional development opportunities: Provide opportunities for students to participate in BIM-related competitions, conferences, seminars, and workshops.	4.93	0.969	0.822	5
C4	Industry partnerships: Provide students with access to industry-standard tools, BIM resources, and guest lectures.	4.89	1.136	0.815	6
C3	Interdisciplinary collaboration: Organizing joint projects or workshops related to BIM involving students from different disciplines.	4.83	1.154	0.806	7
C5	Certification programs: Offer certification programs or examinations in BIM software proficiency.	4.82	1.223	0.804	8
C7	Research and development: Encourage research initiatives focused on BIM topics to contribute to the advancement of BIM technology and practices.	4.69	1.158	0.781	9
C1	Incorporating BIM courses: BIM is taught individually without combining with other knowledge (now it is combined with data management).	4.52	1.124	0.754	10

3.3 Comparative Analysis

Table 8 indicates that all variables deviate from a normal distribution, as a Kolmogorov-Smirnov p-value below 0.05 leads to the rejection of the null hypothesis of normality. Since the data did not follow a normal distribution, the Mann-Whitney U test was carried out, which is a non-parametric test to compare two independent groups. This table compares the readiness of current BIM courses, technical skills, non-technical skills, and improvements observed between students and graduates for each item. The criteria for statistical significance were defined as $z > 1.96$ and $p < 0.05$.

Objective 1 assessed the readiness of existing BIM courses in UTM, a significant difference between the two groups was observed for A1. This item was rated higher by graduates (Mean rank = 50.92) than by students (Mean rank = 40.08), indicating that graduates perceive the integration of BIM courses in universities as more effective in promoting BIM adoption compared to students.

Notable significant differences were observed in four specific items concerning Objective 2, which focuses on technical and non-technical skills. For B1, graduates (Mean rank = 51.47) rated themselves as more proficient in handling interoperability than students (Mean rank = 39.53). Similarly, B2 showed a significant difference, with graduates (Mean rank = 51.59) rating their understanding of regulatory compliance higher than students (Mean rank = 39.41). B5, which relates to information management, organizing, managing, and extracting relevant data from BIM models, also revealed a significant difference, where graduates (Mean rank = 51.23) rated themselves as more competent than students (Mean rank = 39.77). Lastly, B6, which pertains to quantification and estimation, specifically quantity take-off in using BIM, showed a similar trend, with graduates (Mean rank = 51.29) perceiving themselves as more skilled compared to students (Mean rank = 39.71). These findings imply that graduates consistently believe they are more skilled in these technical areas, which is probably due to the extra experience they have after graduating.

For objective 3, which focuses on curriculum improvements, C4 was the only item where a significant difference was observed. Graduates (Mean rank = 50.77) were more likely to perceive industry partnerships as a critical improvement compared to students (Mean rank = 40.23). This could indicate that graduates, having experienced the professional field, recognize the value of exposure to industry-standard tools and resources in preparing students for the workforce.

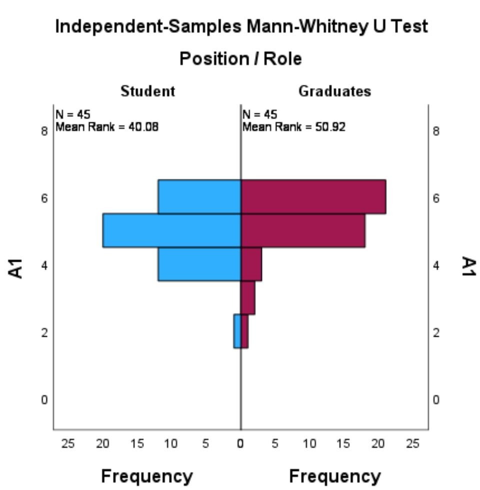
Figure 2 (a) to (f) presents the results of the Mann-Whitney U test for the observed significant groups (A1, B1, B2, B5, B6 and C4). The frequency distribution and mean rank differences are displayed in these figures. The analysis highlights variations in perception across these significant groups, with graduates consistently assigning higher mean ranks than students.

Table 8 Ranking for improvements for BIM integration in the UTM civil engineering curriculum

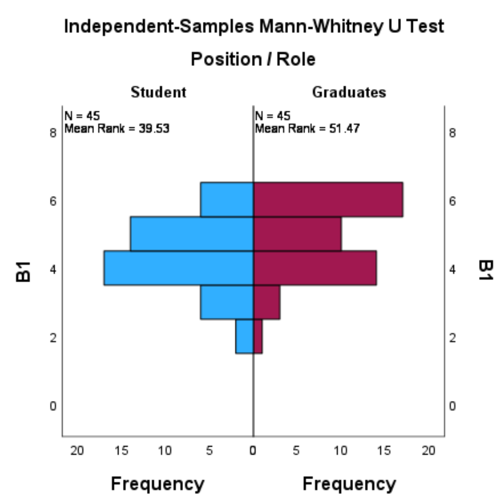
Label	Student (N = 45)			Graduates (N = 45)			Normality test	Mann-Whitney U test	
	Mean	Std. Dev	Rank	Mean	Std. Dev	Rank	Kolmogorov-Smirnov	z	p
A1	4.93	0.863	2	5.24	0.933	1	< 0.001	2.110	0.035*
A2	4.93	1.009	3	5.20	0.842	2	< 0.001	1.320	0.187
A3	4.47	1.140	5	4.29	0.968	7	< 0.001	0.860	0.390
A4	4.02	0.941	9	4.02	1.055	9	< 0.001	0.038	0.970
A5	4.96	0.976	1	5.18	1.114	3	< 0.001	1.695	0.090

A6	3.29	1.471	10	2.84	1.566	10	< 0.001	1.502	0.133
A7	4.36	0.908	7	4.40	0.837	5	< 0.001	0.129	0.897
A8	4.42	1.097	6	4.33	1.066	6	< 0.001	0.422	0.673
A9	4.87	0.944	4	4.98	1.177	4	< 0.001	1.041	0.298
A10	4.13	1.160	8	4.24	1.111	8	< 0.001	0.566	0.571
B1	4.36	1.026	11	4.87	1.079	5	< 0.001	2.256	0.024*
B2	4.29	1.036	13	4.76	1.264	11	< 0.001	2.292	0.022*
B3	4.64	1.131	4	4.96	1.017	3	< 0.001	1.379	0.168
B4	4.47	1.014	10	4.64	1.069	14	< 0.001	0.845	0.398
B5	4.51	1.014	9	4.96	0.999	2	< 0.001	2.175	0.030*
B6	4.27	1.136	14	4.78	1.064	10	< 0.001	2.175	0.030*
B7	4.36	1.190	12	4.67	1.066	13	< 0.001	1.056	0.291
B8	4.56	1.056	7	4.84	1.086	6	< 0.001	1.546	0.122
B9	4.64	1.004	3	4.82	1.051	8	< 0.001	1.064	0.288
B10	4.56	1.013	6	4.67	0.953	12	< 0.001	0.558	0.577
B11	4.80	0.919	1	4.96	1.021	4	< 0.001	1.003	0.316
B12	4.53	0.919	8	4.82	0.936	7	< 0.001	1.396	0.163
B13	4.56	0.893	5	4.80	0.786	9	< 0.001	1.189	0.234
B14	4.73	0.986	2	5.09	0.925	1	< 0.001	1.741	0.082
C1	4.47	1.120	10	4.58	1.138	10	< 0.001	0.539	0.590
C2	4.82	1.114	5	5.11	1.191	3	< 0.001	1.594	0.111
C3	4.69	1.145	9	4.98	1.158	7	< 0.001	1.504	0.133
C4	4.69	1.104	7	5.09	1.145	4	< 0.001	2.010	0.044*
C5	4.80	1.217	6	4.84	1.242	8	< 0.001	0.257	0.797
C6	4.87	1.198	4	5.22	1.064	1	< 0.001	1.547	0.122
C7	4.69	1.124	8	4.69	1.221	9	< 0.001	0.239	0.811
C8	4.87	0.944	2	5.00	1.000	6	< 0.001	0.758	0.449
C9	4.87	1.057	3	5.04	0.999	5	< 0.001	0.819	0.413
C10	4.93	0.963	1	5.11	1.027	2	< 0.001	1.053	0.292

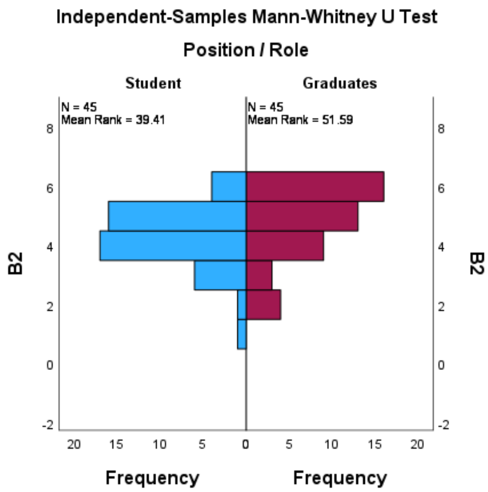
* Significance value at 0.05



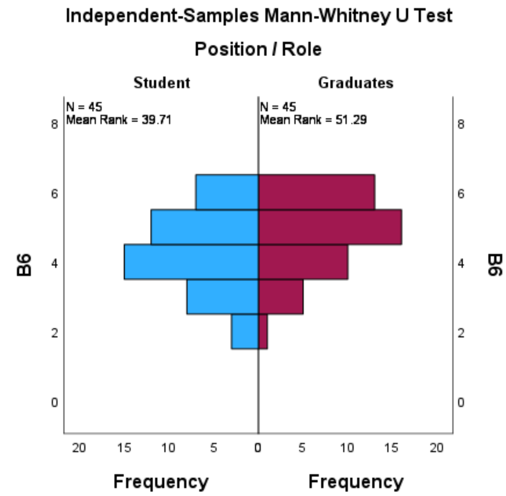
(a) A1



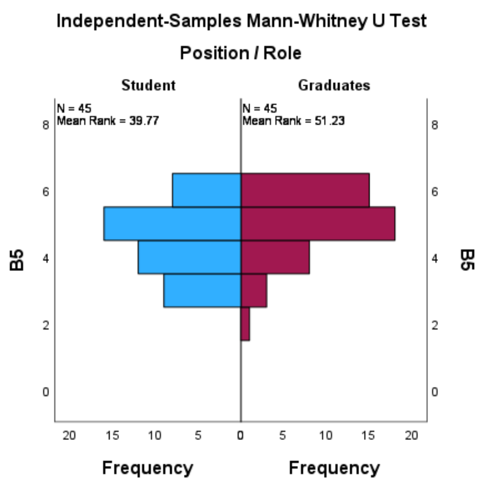
(b) B1



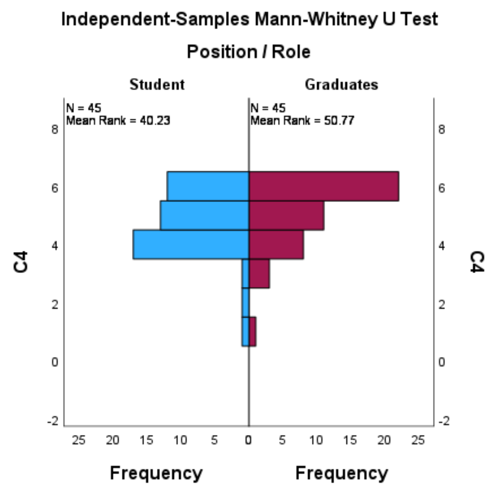
(c) B2



(e) B6



(d) B5



(f) C4

Figure 2 (a) A1, (b) B1, (c) B2, (d) B5, (e) B6, and (f) C4

3.4 Semi-structured Interviews

In this study, semi-structured interviews were conducted after the completion of the survey. The target respondents for the survey were students and graduates, thus the survey responses only reflected student perspectives. There is a need for a qualitative approach to provide further discussion and validate the initial findings. Five experts with BIM experience from different fields were interviewed physically. Table 9 outlines the backgrounds of the five interviewees. All of them have experience with BIM in their careers. By combining the perspectives of both students and industry experts, the study could achieve all objectives more comprehensively. The qualitative data was collected and summarised in Table 10.

Table 9 Background of interviewees

No	Background
R1	An architect who is a certified BIM modeler
R2	A contractor who is using BIM in structural analysis
R3	Project manager
R4	Architectural lecturer with research expertise in BIM
R5	Quantity surveying lecturer and certified BIM instructor

Table 10 Qualitative data

Questions	R1	R2	R3	R4	R5
Do you think that integrating BIM courses in HEIs can enhance BIM adoption in the Malaysian construction industry?	Agree, the students are exposed to BIM knowledge and develop a willingness to enhance their knowledge in the BIM field.	Agree that introducing BIM to university students can increase their awareness of its importance.	Agree, it aligns with current construction trends.	Agree that universities are starting to integrate BIM courses into curricula and paid workshops.	Agree that universities aim to develop graduates with BIM skills to meet industry needs.
What is the current adoption of BIM in the Malaysian construction industry?	BIM has not been fully adopted in Malaysia. It is usually used to fulfil the guidelines but not for its benefits.	The BIM level is limited to 3D modelling. Industries are not aware of BIM benefits throughout the project cycle.	The government has recently started promoting BIM in the construction industry.	Not all consultants in Malaysia are BIM-capable, but the situation is getting better nowadays.	BIM is adopted in government projects at Level 2, while other projects remain at Level 1.
Do you think the existing BIM courses are sufficient to equip fresh graduates with enough knowledge or skills to apply BIM at their workplace?	No, learning BIM is considered a self-initiative.	A basic introduction to BIM is a good start.	Most of the technical aspects of BIM are not well practiced by fresh graduates unless they learn it themselves.	BIM knowledge is an advantage to becoming competitive candidates.	It is not ready yet because BIM is not only a software application, but it also involves management in time, cost and collaboration.
What is the top-ranked BIM-proficient key criteria in the Malaysian construction industry? (Validate the existing ranking)	Agree. The ranking is valid in the Malaysian construction industry. BIM is rarely used in quantity take-off and scheduling.	Partially agree. Modelling skills (B3) are considered a basic skill set for civil engineers. Quantification and estimation (B6) should rank higher.	Partially agree. Modelling skills (B3) and information management (B5) are complicated and need to be compiled by all relevant authorities. Adopting digitalised technologies is encouraged.	Partially agree. In technical skills, project coordination (B4) should be ranked third. In non-technical skills, collaborative working (B8) should rank higher.	Agree, but parametric modelling (B7) should be ranked second in the importance of technical skills, especially for respondents from a civil engineering background who are required to generate models for analysis.
What are the challenges in integrating BIM and the UTM curriculum?	Lack of awareness and financial constraints in buying the software license.	Financial problems and lack of BIM instructors.	The balance between practical application and theory in the syllabus needs improvement.	Software licensing issues and lack of engagement with BIM industries.	Successful implementation requires strategies that incorporate people, processes and technologies.
What are the suggestions for integrating BIM into the UTM curriculum? (Validate the existing ranking)	BIM courses can be implemented in the main syllabus and make good use of student licenses.	Agree. It is encouraged to offer BIM elective courses for one to two semesters.	A deep discussion should be held between BIM industries and course coordinators to include relevant industry practices in the course outline.	Slightly agree. Continuous curriculum updates (C6) through Continuous Quality Improvement (CQI) for every semester.	Agree. Embedding BIM knowledge within existing courses will be one of the strategies to integrate BIM into the civil engineering curriculum.

Following validation through qualitative analysis, some amendments were made to the ranking of technical skills, non-technical skills and suggestions for BIM integration into the UTM curriculum, as illustrated in Figure 3. The modified rankings are highlighted in red. These changes were informed by insights gathered during the interview discussions.

For technical skills, respondents R2, R3 and R4 partially agreed with the ranking and suggested that project coordination should be ranked as the second most important criterion. This statement is supported by Dalloul and Saoud (2023), who found that 4D scheduling, 5D construction cost estimation and integrated project management received a very important grade in their research paper. Besides, they noted that interoperability is less critical as a criterion. In short, project coordination and interoperability were considered to be reordered in the final ranking based on these qualitative insights.

For non-technical skills, all respondents approved the validity of the ranking except respondent R4. Respondent R4 argued that collaborative working should rank higher, as collaboration is a primary objective and benefit of BIM adoption in the construction industry. However, since this perspective did not achieve majority agreement, the original rankings were retained.

Regarding BIM integration suggestions, respondents R1, R2 and R4 proposed that offering BIM-related courses would be the most effective improvements to the current curriculum. Wang et al. (2023) concluded that the extension of BIM from a single course to the curriculum or program level has not been sufficiently demonstrated. Hence, offering BIM-related elective courses is considered an efficient approach to developing competent BIM graduates. In summary, offering BIM-related elective courses was considered to be ranked as the top priority according to qualitative discussion.

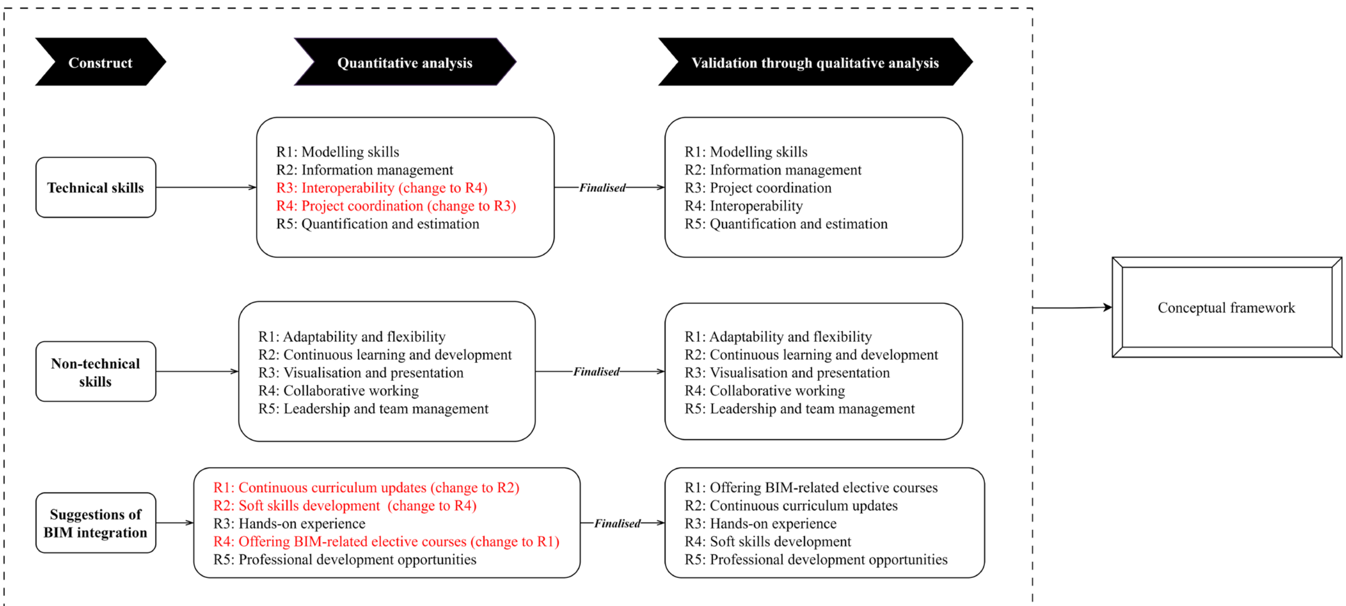


Figure 3 Modification of rankings

3.5 Proposed BIM Conceptual Framework in UTM Civil Engineering Curriculum

The proposed BIM conceptual framework integrates BIM proficiency within the UTM civil engineering curriculum. This framework is based on results obtained from SPSS analysis, semi-structured interviews and literature reviews, which have been adapted from several research studies (Dalloul and Saoud, 2023; Musarat et al., 2023).

First, offering BIM courses was identified as the top-ranked strategy for implementing BIM in the curriculum. This statement was supported by Viana and Carvalho (2021), who claimed that BIM initiatives in undergraduate courses remain limited to introductory levels. Elective courses can be introduced to allow students to explore advanced BIM features, such as BIM software functionalities, data management strategies, execution plans and advanced visualisation techniques, including 4D (time-based scheduling) and 5D (cost estimation) simulations. Al-Ashmori et al. (2022) stated that BIM is rapidly evolving technologies, therefore continuous curriculum updates are necessary after offering BIM-related elective courses in the curriculum. Subsequently, hands-on experience is crucial for the implementation of BIM in the curriculum, enabling students to conduct BIM360, project scheduling and cash flow estimation in BIM courses. This hands-on experience is suggested to be part of the assessments in these courses.

Next, the framework focuses on soft skills development, particularly non-technical skills such as adaptability and flexibility, and collaborative working. To enhance students' BIM skills and knowledge, projects should be designed in a combination of individual and group settings. For example, simulation tools and role-playing scenarios allow students to simulate real-world BIM projects. It improves the collaboration between students to practice adaptability and flexibility in dealing with unexpected challenges and changes in project requirements.

Lastly, professional development opportunities encourage students to participate in BIM competitions. Syafika et al. (2022) mentioned that incorporating the BIM syllabus in the academic curriculum and providing sufficient BIM training and seminars as one of the BIM implementation strategies. With that, students are provided with industry exposure and networking opportunities to enhance their BIM expertise and career readiness. The conceptual framework is shown in Figure 4.

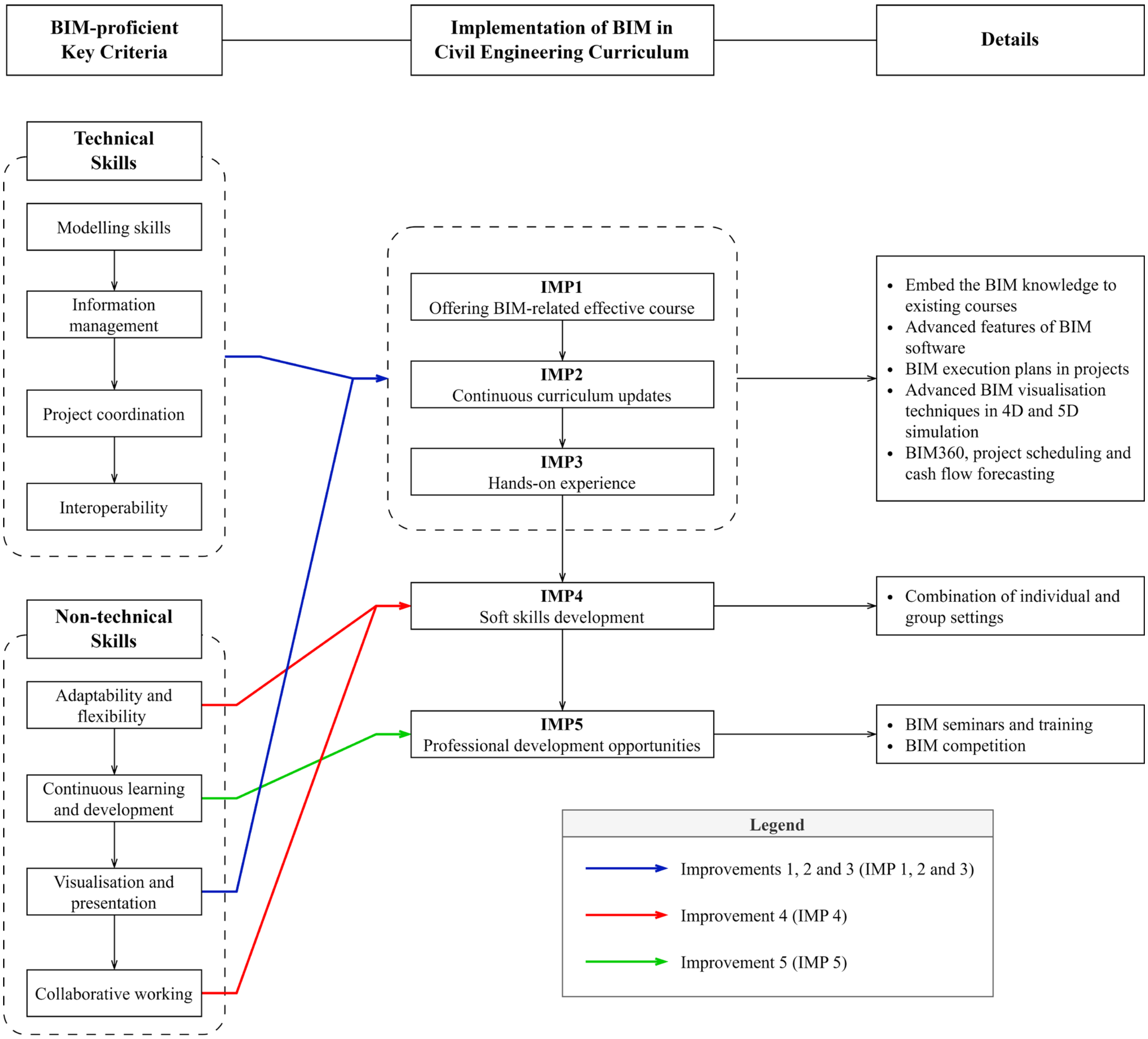


Figure 4 Conceptual framework

4. Conclusion

This study successfully achieved three objectives. The first objective was to identify the readiness of existing BIM courses to produce BIM-proficient graduates. The findings indicate that the current course in the civil engineering curriculum at UTM is insufficient and requires further improvement due to insufficient technical depth and limited BIM knowledge. These gaps can be addressed through the proposed conceptual framework, which provides structured curriculum enhancements to better align with industry demands. The second objective was to assess the key criteria for BIM proficiency within the Malaysian construction industry. They are divided into technical and non-technical skills. Through questionnaires, semi-structured interviews and literature reviews, the top-ranked technical skills are modelling skills, information management, project coordination and interoperability. For non-technical skills, the most important criteria were adaptability and flexibility, continuous learning and development, collaborative working, and visualisation and presentation. The third objective was to validate the integration of BIM into the UTM civil engineering curriculum. To achieve this, a conceptual BIM integration framework was developed. This framework outlines the technical and non-technical skills required for each improvement of BIM integration within the curriculum, including offering BIM-related elective courses, continuous curriculum updates, hands-on experience, soft skills development and professional development opportunities. It also serves as a guiding reference for faculty management to refine and update the curriculum to ensure that future graduates are equipped with BIM proficiency to meet industry demands and thrive in the evolving construction sector.

This study contributes to the enhancement of BIM education in Malaysia by providing curriculum recommendations that align with industry competency requirements. By equipping graduates with essential BIM skills, this study supports improved workforce readiness, innovation and competitiveness in the Malaysian construction and engineering sectors. Based on empirical findings, this study provides actionable recommendations for universities and educators on effectively integrating BIM into curricula. These recommendations address curriculum design, faculty development, resource allocation, and collaboration with industry partners.

While the study's findings were initially derived from UTM, their implications could apply to other universities as well. These institutions can benefit from adopting similar curricular strategies by adapting the proposed conceptual framework to their unique institutional contexts and resources. For instance, institutions can draw lessons from UTM's experiences by building close partnerships with industry stakeholders and creating systems for ongoing feedback to keep their curriculum up-to-date. By bridging the gap between academic preparation and industry expectations, the conceptual framework developed in this study sets the foundation for more effective BIM implementation in the UTM civil engineering curriculum.

However, it is important to acknowledge the limitations of this study. Firstly, the data was sourced solely from UTM students majoring in civil engineering. Hence, the findings may not fully capture the requirements for BIM competence personnel in the Architecture, Engineering, Construction and Operation (AECO) industry. Secondly, while the response rate of 48.65% in this study is considered acceptable, response bias may still exist. This potential bias should be carefully considered in future research when interpreting the findings.

For future work directions, it is important to assess the content validity of the questionnaire before distribution to ensure that the measurement items are relevant. Besides, future studies should encourage cross-university collaboration involving faculties of civil engineering from different universities to achieve larger and diverse sample sizes. The findings can be compared across different contexts, which could help improve the generalisability of the findings. Lastly, future research could focus on developing standardisation of BIM teaching guidelines for undergraduate curricula, which would help create more consistent educational practices across institutions.

Acknowledgements

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

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

References

Ahankoob, A., Manley, K., & Abbasnejad, B. (2022). The role of contractors' building information modelling (BIM) experience in realising the potential values of BIM. *International Journal of Construction Management*, 22(4): 588-599. DOI: https://doi.org/10.1080/15623599.2019.1639126

Al-Ashmori, Y. Y., Othman, I., & Al-Aidrous, A.-H. M. H. (2022). Values, Challenges, and Critical Success Factors of Building Information Modelling (BIM) in Malaysia: Experts Perspective. *Sustainability*, 14(6): 3192. DOI: https://doi.org/10.3390/su14063192

Alaloul, W. S., Qureshi, A. H., En, Y. P., Khan, S. A., Musarat, M. A., Alzubi, K. M., & Salaheen, M. A. (2023). Survey Evaluation of Building Information Modelling (BIM) for Health and Safety in Building Construction Projects in Malaysia. *Sustainability*, 15(6): 4899. DOI: https://doi.org/10.3390/su15064899

Arroteia, A. V., Freitas, R. C., & Melhado, S. B. (2021). Barriers to BIM adoption in Brazil. *Frontiers in Built Environment*, 7: 520154. DOI: https://doi.org/10.3389/fbuil.2021.520154

Aziz, N. M., & Zainon, N. (2023). Driving factors for lean-BIM implementation in Malaysia's construction industry: qualitative interview-based study. *Smart and Sustainable Built Environment*, 12(4): 872-891. DOI: https://doi.org/10.1108/SASBE-01-2022-0019

Azman, N. S., Ramli, M. Z., Razman, R., Zawawi, M. H., Ismail, I. N., & Isa, M. R. (2019). Relative importance index (RII) in ranking of quality factors on industrialised building system (IBS) projects in Malaysia. *AIP Conference Proceedings*, 2129, DOI: https://doi.org/10.1063/1.5118037

Belayutham, S., Zabidin, N. S., & Che Ibrahim, C. K. I. (2018). Dynamic representation of barriers for adopting building information modelling in Malaysian tertiary education. *Construction Economics and Building*, 18(4): 24-44. DOI: https://doi.org/10.5130/AJCEB.v18i4.6228

Brahim, J., Yusoff, S. N. S., & Mat Yusoff, Z. (2021). Incorporation of building information modelling (BIM) in Malaysian higher education institutions: a review. *Built Environment Journal (BEJ)*, 18(1): 15-22.

Casasayas, O., Hosseini, M. R., Edwards, D., Shuchi, S., & Chowdhury, M. (2021). Integrating BIM in higher education programs: Barriers and remedial solutions in Australia. *Journal of Architectural Engineering*, 27(1): 05020010. DOI: https://doi.org/10.1061/(ASCE)AE.1943-5568.000044

Chaokromthong, K., & Sintao, N. (2021). Sample size estimation using Yamane and Cochran and Krejcie and Morgan and green formulas and Cohen statistical power analysis by G* Power and comparisions. *Apheit international journal*, 10(2): 76-86.

CIDB. (2020). Construction 4.0 Strategic Plan (2021-2025). https://www.cream.my/construction-4-0-strategic-plan-2021-2025. Retrieved on 30 September 2024

CIDB. (2022). Malaysia Building Information Modelling (BIM) Report 2021.https://smart.cidb.gov.my/publication/malaysia-building-information-modelling-bim-report-2021-457 Retrieved on 30 September 2024

Dalloul, F., & Saoud, L. (2023). Proposing a framework for introducing the concept of engineering digitization to develop curricula: case study-Tishreen University, Faculty of Civil Engineering. *International Journal of BIM and Engineering Science*, 6(1): 34-51. DOI: http://dx.doi.org/10.54216/IJBES.060103

Del Savio, A. A., Galantini Velarde, K., Díaz-Garay, B., & Valcárcel Pollard, E. (2022). A Methodology for Embedding Building Information Modelling (BIM) in an Undergraduate Civil Engineering Program. *Applied Sciences*, 12(23): 12203. DOI: https://doi.org/10.3390/app122312203

Guo, B. H. W., Gonzalez, V. A., Puolitaival, T., Enegbuma, W., & Zou, Y. (2023). Bridging the gap between building information modelling education and practice: a competency-based education perspective. International *Journal of Construction Management*, 23(15): 2558-2569. DOI: https://doi.org/10.1080/15623599.2022.2077546

Hadavi, A., & Alizadehsalehi, S. (2024). From BIM to metaverse for AEC industry. *Automation in Construction*, 160: 105248. DOI: https://doi.org/10.1016/j.autcon.2023.105248

Jiang, Z. (2021). Research on the development of BIM technology based on the application in the field of civil engineering. *E3S Web of Conferences*, DOI: https://doi.org/10.1051/e3sconf/202126103025

Jin, R., Zou, P. X., Li, B., Piroozfar, P., & Painting, N. (2019). Comparisons of students' perceptions on BIM practice among Australia, China and UK. *Engineering, Construction and Architectural Management*, 26(9): 1899-1923. DOI: https://doi.org/10.1108/ECAM-07-2018-0275

Kusmaryono, I., Wijayanti, D., & Maharani, H. R. (2022). Number of Response Options, Reliability, Validity, and Potential Bias in the Use of the Likert Scale Education and Social Science Research: A Literature Review. *International Journal of Educational Methodology*, 8(4): 625-637. DOI: https://doi.org/10.12973/ijem.8.4.625

Le, N., Er, M., & Sankaran, S. (2018). Building Information Modeling (BIM) Adoption and Implementation: Interaction Between BIM Users and Non-BIM Users. *Proceedings of International Structural Engineering and Construction*, 5. DOI: https://doi.org/10.14455/ISEC.res.2018.75

lot Tanko, B., & Mbugua, L. (2022). BIM education in higher learning institutions: a scientometric review and the Malaysia perspective. *International Journal of Built Environment and Sustainability*, 9(1): 23-37. DOI: https://doi.org/10.11113/ijbes.v9.n1.864

Mehranfar, M., Vega-Torres, M. A., Braun, A., & Borrmann, A. (2024). Automated data-driven method for creating digital building models from dense point clouds and images through semantic segmentation and parametric model fitting. *Advanced Engineering Informatics*, 62: 102643. DOI: https://doi.org/10.1016/j.aei.2024.102643

Musarat, M. A., Alaloul, W. S., Cher, L. S., Qureshi, A. H., Alawag, A. M., & Baarimah, A. O. (2023). Applications of Building Information Modelling in the Operation and Maintenance Phase of Construction Projects: A Framework for the Malaysian Construction Industry. *Sustainability*, 15(6): 5044. DOI: https://doi.org/10.3390/su15065044

Ng, H. T., & Aryani, A. L. (2022). Identification of Skills among BIM Coordinators in the Malaysian Construction Industry. *Journal of Technology Management and Business*, 9(1): 20-26. https://penerbit.uthm.edu.my/ojs/index.php/jtmb/article/view/11846

Onungwa, I., Olugu-Uduma, N., & Shelden, D. R. (2021). Cloud BIM Technology as a Means of Collaboration and Project Integration in Smart Cities. *Sage Open*, 11(3): 21582440211033250. DOI: https://doi.org/10.1177/21582440211033250

Raja Mohd Noor, R. N. H., Che Ibrahim, C. K. I., & Belayutham, S. (2023). The nexus of key attributes influencing the social collaboration among BIM actors: a review of construction literature. International *Journal of Construction Management*, 23(6): 988-998. DOI: https://doi.org/10.1080/15623599.2021.1946902

Sampaio, A. Z. (2022). Introducing BIM in Curricular Programs of Civil Engineering. *International Journal of Higher Education*, 11(1): 31-42. DOI: https://doi.org/10.5430/ijhe.v11n1p31

Seng, N. H., Teng, N. C., Noor, N. M., Umar, S., Wei, N. T., Boon, K. H., & Ling, F. T. C. (2025). BIM Implementation in Malaysian Quantity Surveying: A Conceptual Framework for Success Aligned with the Strategic Plan 2021-2025. *Diyala Journal of Engineering Sciences*, 55-69. DOI: https://doi.org/10.24237/djes.2025.18103

Silva, T. F., Arroteia, A. V., Vieira, D. R., Melhado, S. B., & Carvalho, M. M. (2021). Exploring the influence of risks in BIM implementation: A review exploring BIM critical success factors and BIM implementation phases. *The Journal of Modern Project Management*, 8(3). DOI: https://doi.org/10.19255/JMPM02511

Syafika, N., Rahim, A., Ismail, S., Aminah, & Taylor, G. (2022). Implementation Strategies of Building Information Modelling towards Sustainable Residential Construction Project in Malaysia. *Civil Engineering and Architecture*, 10: 1556-1563. DOI: https://doi.org/10.13189/cea.2022.100425

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, 48(6): 1273-1296. DOI: https://doi.org/10.1007/s11165-016-9602-2

Taherdoost, H. (2019). What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. *Hamed Taherdoost*, 1-10.

Tsai, M.-H., Chen, K.-L., & Chang, Y.-L. (2019). Development of a Project-Based Online Course for BIM Learning. *Sustainability*, 11(20): 5772. DOI: https://doi.org/10.3390/su11205772

UKM. (2022). Civil Engineering Programme 2022/2023. https://www.ukm.my/jurutera/en/undergraduate-handbook-for-academic-session-2022-2023/ Retrieved on 30 September 2024

UM. (2023). Program Handbook Session 2023/2024. https://engine.um.edu.my/bachelor-of-civil-engineering. Retrieved on 30 September 2024

UPM. (2021). Undergraduate Study Programme Hand Book Session 2021/2022. https://eng.upm.edu.my/akademik/akademik_prasiswazah/skema_pengajian-3464?L=en Retrieved on 30 September 2024

UTM. (2022). Academic Guidelines Faculty of Civil Engineering Session 2022/2023. https://civil.utm.my/undergraduate/academic-guidelines/ Retrieved on 25 August 2025

Viana, V. L. B., & Carvalho, M. T. M. (2021). Prioritization of risks related to BIM implementation in brazilian public agencies using fuzzy logic. *Journal of Building Engineering*, 36: 102104. DOI: https://doi.org/10.1016/j.jobe.2020.102104

Wang, L., Huang, M., Zhang, X., Yan, X., Jin, R., Wanatowski, D., Cheshmehzangi, A., & Chohan, N. (2023). Incorporating BIM into the upper-division curriculum of construction engineering and management. *European Journal of Engineering Education*, 48(3): 482-501. DOI: https://doi.org/10.1080/03043797.2022.2112150

Wang, L. Y., Huang, M. P., Zhang, X. H., Jin, R. Y., & Yang, T. (2020). Review of BIM Adoption in the Higher Education of AEC Disciplines. *Journal of Civil Engineering Education*, 146(3): 06020001. DOI: https://doi.org/10.1061/(asce)ei.2643-9115.0000018

Wu, M.-J., Zhao, K., & Fils-Aime, F. (2022). Response rates of online surveys in published research: A meta-analysis. *Computers in Human Behavior Reports*, 7: 100206. DOI: https://doi.org/10.1016/j.chbr.2022.100206

Yusuf, B. Y., Embi, M. R., & Ali, K. N. (2017). Academic readiness for building information modelling (BIM) integration to Higher Education Institutions (HEIs) in Malaysia. *2017 International Conference on Research and Innovation in Information Systems (ICRIIS)*.