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BIM IMPLEMENTATION AND ITS BENEFITS FOR DIPLOMA IN ARCHITECTURE STUDENTS IN UNIVERSITI TEKNOLOGI MALAYSIA

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Abstract: **The incorporation of Building Information Modeling (BIM) technology into architectural education has gained increasing importance in preparing upcoming architects for evolving industry standards. This study delves into the crucial factors that contribute to the successful adoption of BIM within the Diploma in Architecture program at Universiti Teknologi Malaysia (UTM). It encompasses a thorough literature review along with a questionnaire survey to meet the research objectives, followed by statistical analysis to interpret the collected data.**

This research not only sheds light on the status of BIM integration within UTM's Diploma in Architecture program but also offers practical suggestions for enhancing the incorporation of BIM technology into architectural education more broadly. The outcomes of this study can guide curriculum enhancements and institutional policies to better equip students with the necessary skills and knowledge for success in the architecture industry.

Three main research objectives were identified: (i) to pinpoint critical success factors in BIM implementation for architectural education, (ii) to assess the significance and its benefits of BIM in the eyes of Diploma students and its application, and (iii) to evaluate the BIM competency levels within Diploma in Architecture education. The research targeted data collection and the population at the Centre of Diploma Studies, SPACE UTM, in Kuala Lumpur and Johor Bahru, focusing on students enrolled in the Diploma Architecture program and emphasizing the learning benefits of BIM for architectural education at the Diploma level.

Keywords: **Building Information Modeling (BIM), architectural education, critical success factors, curriculum integration, BIM implementation, Building Information Modeling (BIM) in Architectural Education.**

I. INTRODUCTION

This study provides an examination of critical success factors contributing to the successful implementation of Building Information Modeling (BIM) in Universiti Teknologi Malaysia's (UTM) Diploma in Architecture program. The objective of this research was to gain insights into the benefits and students' competency levels in utilizing BIM within the program. Through thorough literature review and surveys administered to Diploma Architecture students, the study seeks to pinpoint pivotal elements for the effective implementation of BIM in UTM's Diploma in Architecture program.

The significance of BIM technology is growing among Architecture students at Universiti Teknologi Malaysia. Building Information Modeling (BIM) is a digital tool that facilitates collaboration among architects, engineers, and construction professionals in designing and constructing buildings. Mastering BIM technology equips students in the Built Environment

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field with valuable skills and expertise, enhancing their competitiveness in the job market. They can develop detailed 3D building models that accurately represent design and materials, fostering better collaboration and communication among project stakeholders.

Additionally, BIM technology streamlines construction processes, leading to cost savings, error reduction, and improved overall project quality. As the construction industry increasingly adopts BIM, students proficient in its usage are in high demand among employers. Overall, mastering BIM technology equips architecture students at Universiti Teknologi Malaysia with essential knowledge and skills that will benefit them throughout their careers in the construction industry.

II. LITERATURE REVIEW

A. BIM in Architecture Education

Conventional approaches to design and production have become entrenched in contemporary architecture programs (Harriss, 2016; Prensky, 2001). However, due to the advancement in computing and construction technology, these methods have slowly become outdated, as new software and technology are steadily being prioritized (Hossain & Zaman, 2022). Even Though the rate differs across geography, a rising trend can be seen (Hurst, 2022). This warrants the question of; how BIM is included in architectural education in general.

In their research, Hossain and Zaman (2022) explored the need for introducing BIM technology to undergraduate architecture students in Bangladesh. They determined that BIM and CAD courses should be integrated into the curriculum once students have established a foundational understanding of architectural design and drafting, typically during the second year of the undergraduate program.

Zhou et al. (2022) argue that there exists a significant disparity between the education on Building Information Modeling (BIM) in universities and the industry's demands. They highlight that current architecture education primarily emphasizes theoretical and knowledge-based approaches rather than equipping students with multidisciplinary problem-solving skills. Zhou et al. (2022) emphasize that the scarcity of BIM professionals in the construction sector can be attributed to two main factors: inadequate training of BIM modeling engineers during university education, and inadequate talent management practices. The former arises from the deficiency in providing engineering-specific skills within university programs, while the latter results from the absence of effective strategic planning and talent management systems.

Digitally driven processes and thinking in architectural education promote innovative communications, similar to the working environment of BIM (Schnabel, 2012). Zhou et al. (2022) state that the training of BIM in universities should go beyond basic knowledge, to include creative and innovative aspects of BIM technology. Zhou et al. (2022) argue that structured BIM internships during graduate studies are essential for nurturing students' practical skills development.

In an effort to reduce the gap between academics and industries, Zhou et al. (2022) propose that formal BIM education and training include factors such as training purpose, execution method, and implementation focus. Firstly, training purpose that teaches the basics of theories and practices. Secondly, an execution method that integrates full-time tutors and professional tutors. This allows full-time tutors to teach theories related to BIM, while professional tutors will teach basic operation of BIM software. Thirdly, the implementation focus uses case studies to reduce the gap between university and workplace reality.

Zhou et al. (2022) also propound that teachers should consider the actual condition of students. Since students' abilities and interests vary, teachers should be able to identify their unique strengths and weaknesses beforehand and develop them accordingly to their maximum potential.

A comprehensive review of the current literature regarding Building Information Modeling (BIM) for diploma students in architecture, focusing on overarching trends and observations. The field of BIM and architectural education is rapidly evolving, and there might be new developments and research findings beyond that point.

a) Integration of BIM in Architectural Curriculum:

The literature highlights a growing trend towards integrating BIM into architectural education. Many programs recognize the importance of teaching BIM skills to undergraduate students, aligning the curriculum with industry demands. However, there are varying levels of integration, with some programs providing comprehensive BIM training while others offer limited exposure.

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b) Pedagogical Approaches:

There's a diversity of pedagogical approaches to teaching BIM to undergraduate architecture students. Some studies emphasize hands-on, project-based learning where students engage with real-world BIM projects. Some emphasize theoretical aspects, instructing BIM principles and methodologies. The efficacy of these methods varies, highlighting the necessity for additional research to compare diverse teaching approaches.

c) Challenges in Implementation:

Literature often discusses challenges faced by educators and students in implementing BIM education. Limited access to software, lack of qualified instructors, and resistance to change within educational institutions are common obstacles. Additionally, there are challenges in assessing students' BIM skills effectively, especially considering the diverse nature of BIM applications.

d) Industry Alignment and Employability:

Many studies emphasize the importance of aligning BIM education with industry standards and practices. BIM skills are highly valued in architecture and construction industry, and programs that closely align their curriculum with industry demands tend to produce more job- ready graduates. However, there's a gap between what is taught in academia and what the industry requires, indicating a need for closer collaboration between educators and practitioners.

e) Assessment and Evaluation:

Assessing students' BIM proficiency is a topic of interest. Traditional assessment methods are often deemed insufficient to evaluate BIM skills comprehensively. Some studies explore innovative assessment techniques, such as online portfolios, collaborative projects, or industry- relevant certification exams, to provide a more accurate evaluation of students' abilities.

f) Lifelong Learning and Continuing Education:

The literature suggests the importance of fostering a culture of lifelong learning in BIM. Given the rapid technological advancements, there's a need for continuous education even after graduation. Some programs incorporate mechanisms for students to stay updated with the latest BIM tools and methodologies, ensuring their skills remain relevant throughout their careers.

g) Global Perspectives:

Research in BIM education often takes a global perspective, comparing approaches and challenges across different countries and regions. This comparative analysis provides valuable insights into the diverse methods used to teach BIM worldwide, contributing to a broader understanding of effective educational practices.

In conclusion, while there has been significant progress in integrating BIM into architectural education, challenges related to pedagogy, resources, assessment, and industry alignment persist. Further research is necessary to address these challenges, develop standardized assessment methods, and explore innovative pedagogical approaches to ensure that undergraduate students receive a comprehensive and industry-relevant BIM education. Additionally, staying updated with the latest technological advancements and industry practices remains crucial for both educators and students in the field of BIM.

B. BIM Implementation

Handayani and Putri (2021) suggest that BIM is typically utilized in three distinct manners. Initially, as BIM authoring, aiming to produce visual depictions of buildings comprising multiple elements. Secondly, through visualization using 3D coordination, enhancing comprehension of building conditions. Thirdly, BIM can be employed in phase planning or scheduling by integrating temporal aspects into the 3D model.

In their study, Handayani and Putri (2021) suggest implementing BIM to enhance project scheduling by elaborating on prerequisite activities. They argue that current project schedules often lack specific levels of detail, particularly regarding prerequisite activities such as plant installation, material supply, and document preparation. Addressing these activities is crucial for streamlining overall construction management and time management processes.

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III. METHODOLOGY

A. Study Design

The aim of the literature review was to gain a more profound insight into the critical success factors in this field and to enhance understanding regarding the use of BIM as a tool for architectural communication within the UTM Diploma program. By conducting a thorough analysis of pertinent literature, critical success factors specific to implementing BIM in architectural education for UTM Diploma students were identified, as outlined in Table 1.

TABLE I: CRITICAL SUCCESS FACTORS

No.	Factor
F1	Improve Academic Performance
F2	Increase the Use of Quality Data to Drive Instruction
F3	Increase Leadership Effectiveness
F4	Increase Parent/ Community
F5	Increased Learning Time
F6	Improve School Climate
F7	Increase Teacher Quality

B. Questionnaire Survey

A questionnaire survey was utilized as the data collection method. Stratified sampling was employed to distribute 219 sets of questionnaires among first-year, second-year, and third-year students. Table 2 presents the respondent details, with 28 sets completed by first-year students, 57 by second-year students, and 46 by third-year students. The overall response rate reached 59.5%, with 131 completed questionnaire sets returned.

TABLE 2: DETAIL OF RESPONDENTS

No.	Student's Year	Frequency (N)	Response rate %
1	First year	70	40 %
2	Second year	73	78 %
3	Third year	76	60.5 %

The survey questionnaire was segmented into four sections: Sections A, B, and C. Section A inquired about the demographics and backgrounds of the participants, Section B focused on their comprehension level regarding BIM model application, and Section C sought their opinions on the appropriate LOD (Level of Development) for diploma architecture students.

IV. RESULTS AND DISCUSSION

A. Respondents Demographic

The survey conducted by 131 Diploma in Architecture students at SPACE UTM revealed that the largest portion, accounting for 21.4%, came from first-year students. Following closely were second-year students, comprising 44.3%, while third-year students represented 34.4% of the respondents. All participants were local students who were actively enrolled for the first semester of the 2023/2024 session.

B. Results and Discussion

TABLE 3: FAMILIARITY OF RESPONDENTS TOWARDS BUILDING INFORMATION MODELLING (BIM)

Student's Year		Are you familiar with BIM					Total
		Very Unfamiliar	Unfamiliar	Neutral	Familiar	Very Familiar	
First year	Count	7	3	10	6	2	28
	% of Total	25%	10.7%	35.7%	21.4%	7.1%	
Second year	Count	5	15	17	15	5	57
	% of Total	8.7%	26.3%	29.8%	26.3%	8.8%	

Third year	Count	2	8	23	7	6	46
	% of Total	4.3%	17.4%	50%	15.2%	13%	
Total	Count	14	26	50	28	13	131
	% of Total	10.7%	19.8%	38.2%	21.4%	9.9%	

Table 3 illustrates the data concerning the present level of familiarity with Building Information Modeling (BIM) among students, categorized according to their academic level within the program. The responses indicate varying levels of familiarity with BIM among first-year, second-year, and third-year students. Firstly, the table shows that among first-year students, the percentage of those familiar with BIM stands at 7.1%. This suggests that a relatively small proportion of students in their first year of the program have a good understanding or exposure to BIM concepts and practices. Secondly, among second-year students, the percentage of BIM familiarity is slightly higher at 8.8%. This indicates a modest increase in BIM knowledge or exposure compared to first-year students but still falls short of a significant proportion of the student body. Lastly, the data reveals that third-year students exhibit the highest level of BIM familiarity among the three groups, with a percentage of 13%. This finding suggests that as students' progress through their program and gain more experience and exposure to industry-related technologies such as BIM, their familiarity and understanding also tend to increase significantly.

These findings highlight a potential trend where students' exposure and understanding of BIM tend to improve as they advance through their academic program. However, it also underscores the importance of enhancing BIM education and exposure across all levels of the program to ensure that students are adequately prepared with the necessary skills and knowledge for the industry upon graduation. This could involve integrating BIM-related coursework, workshops, internships, and practical projects into the curriculum to facilitate a more comprehensive and effective learning experience.

TABLE 4: BENEFITS OF BIM IMPLEMENTATION

No.	BIM Benefits and Capabilities	Mean (M)	Rank
1	Better understanding via model visualization	4.12	1
2	Eliminate clashes in design.	1.61	8
3	Improved productivity and efficiency for design production	3.7	2
4	Improved communication between students & lecturers	2.25	5
5	Effective and accurate project time planning and sequencing	2.45	4
6	Ability to integrate time and cost which supports real-time update.	2.06	6
7	Can apply in the assessment and analysis of green building.	2.52	3
8	Can be used for clashes detection and design optimization.	2.06	7

Table 4 highlights eight benefits of Building Information Modelling (BIM) based on Adhikari et al, 2020 and Saraire & Haron 2020, which provides insights into the perceived advantages of utilizing Building Information Modelling.

An overwhelming majority in first rank by (M=4.12) of respondents acknowledge that one of the primary benefits of BIM is the improved understanding facilitated by model visualization. This suggests that the visual representation of data through BIM is highly valued for enhancing comprehension. (M=1.61) recognizes BIM's capability to eliminate clashes in design. This indicates that a subset of respondents appreciates BIM as a tool for identifying and resolving conflicts in the design process. A significant portion recognizes BIM as a valuable tool for enhancing productivity and efficiency in the design production process. This implies that BIM is perceived to streamline and optimize design workflows. Approximately half of the participants recognize the efficacy of BIM in aiding precise project time planning and sequencing. This suggests that BIM is perceived as a tool that enhances project scheduling and timeline management.

A substantial mean value, which in rank number 5 recognizes the role of BIM in improving communication between students and lecturers. This suggests that BIM is perceived as a valuable educational tool for enhancing communication in academic settings. In rank number 6, respondents acknowledge the ability of BIM to integrate time and cost, supporting real-time updates. This indicates that BIM is seen as a tool that allows for dynamic adjustments based on changing project parameters. The majority, ranking at number 3, acknowledges the relevance of BIM in evaluating and analyzing green building practices. This indicates that BIM is viewed as a valuable tool for promoting sustainable and environmentally conscious design and construction practices. A significant portion also recognizes the usefulness of BIM in clash detection and design optimization. This implies that BIM is considered an effective tool for enhancing and refining the design process.

TABLE 5: Does BIM can improve Studio Project

Student's Year		Will BIM help to improve Studio Project?		Total
		Yes	No	
First year	Count	28	0	28
	% of Total	100%	0%	
Second year	Count	53	4	57
	% of Total	93%	7%	
Third year	Count	44	2	46
	% of Total	95.7%	4.3%	
Total	Count	125	6	131
	% of Total	95.4%	4.6%	

According to the findings from Table 5, the data analysis conducted unveiled a highly positive attitude among students regarding the influence of Building Information Modeling (BIM) on their studio projects. Specifically, 95.4% of the surveyed students expressed agreement with the notion that incorporating BIM methodologies significantly enhances the quality and efficacy of their studio projects.

Furthermore, the data implies that the integration of BIM into the curriculum has a direct and positive impact on students' ability to navigate real-world project challenges. By engaging with BIM tools and methodologies, students gain invaluable experience that aligns with industry standards and prepares them for successful careers in their respective fields. Overall, these findings validate the pedagogical significance and practical relevance of BIM education in enhancing students' studio projects and professional readiness.

TABLE 6: BIM improvement of Students Project

No.	BIM improvement	Mean (M)	Rank
1	Structures & Constructions	4.2	1
2	Drawings	3.32	2
3	Materiality	2.1	6
4	Modelling	3.13	3
5	Time management	2.14	5
6	Design process	3.02	4
7	Design amendment	1.57	7

The research findings from our study provide compelling evidence supporting the widespread positive impact of Building Information Modelling (BIM) across various crucial domains within the realms of structures, constructions, and design processes.

Firstly, a substantial majority of respondents with (M=4.2) expressed agreement regarding the significant enhancements that BIM brings to Structures & Constructions. This reflects a consensus among participants that BIM contributes significantly to improving quality, efficiency, and overall success of projects in these areas. Such improvements likely include better coordination among project teams, reduced errors, enhanced visualization capabilities, and improved communication channels among stakeholders.

Additionally, respondents acknowledged notable improvements in Drawings quality with (M=3.32) facilitated by BIM technology. This encompasses benefits such as increased accuracy and detail in drawings, streamlined revision processes, faster generation of construction documentation, and improved integration across different drawing sets.

The research also highlighted the enhanced Modelling accuracy achieved through BIM adoption. This aspect signifies the capability of BIM to create and manage highly accurate digital models, aiding in clash detection and resolution during design phases, providing better visualization for stakeholders, and enabling detailed analysis of structural and environmental factors.

Furthermore, participants recognized the positive impact of BIM on Design process efficiency, indicating improvements in collaboration among architects, engineers, and other project stakeholders. BIM facilitates iterative design improvements based on real-time data and feedback, enhances visualization of design concepts, and supports informed decision-making throughout the design phases.

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While a lower mean score of respondents acknowledged benefits in specific areas such as Time management practices (M=2.14), Materiality management (M=2.1), and aiding Design amendments (M=1.57), these findings still underscore the valuable contributions of BIM in streamlining project schedules, optimizing material selection and management processes, and facilitating faster and more accurate design iterations and amendments.

These detailed insights into the research outcomes highlight not only the multifaceted benefits of BIM but also emphasize its transformative potential in revolutionizing traditional workflows, fostering better collaboration among project teams, and ultimately leading to improved project outcomes and overall industry efficiency. These discoveries carry substantial implications for the wider acceptance and incorporation of BIM methodologies within construction and design industries.

TABLE 7: BIM Level of Development

No.	Level of programme	Frequency (N)	Percentage %
1	LOD 1	7	5.3%
2	LOD 2	14	10.7%
3	LOD 3	72	55%
4	LOD 4	25	19.1%
5	LOD 5	13	9.9%

The analysis of the research data underscores a compelling inclination among diploma students towards BIM Level of Development (LOD) 3 - Design Development, which garnered the highest preference at 55%. This finding suggests that students in architectural education value detailed modeling and comprehensive representation of elements such as specific components, quantities, size, shape, location, and orientation during the critical phase of design development. The significant preference for LOD 3 aligns with the stage where design ideas evolve into refined concepts, necessitating thorough modeling for enhanced visualization, coordination, and design decision-making.

Additionally, this research highlights a notable interest among students in BIM LOD 4 - Construction Stage, which garnered a preference rate of 19.1%. This preference indicates that students recognize the importance of detailed modeling at the construction phase, encompassing fabrication, assembly, and detailing information crucial for construction planning, coordination, and execution. The interest in LOD 4 reflects students' awareness of the role of BIM in facilitating seamless collaboration among various stakeholders during the construction process, ultimately contributing to improved project outcomes and efficiencies.

While LOD 3 and LOD 4 emerged as preferred levels among students, it's essential to note the varying percentages for other LODs as well. LOD 1 - Pre-Design (5.3%) and LOD 2 - Schematic Design (10.7%) represent students' recognition of the basic modeling needs in early conceptual and schematic stages, respectively. Furthermore, the consideration for LOD 5 - As-Built (9.9%) indicates an understanding of the importance of capturing as-built details for facility management and post-construction documentation.

These findings not only shed light on students' preferences but also emphasize the relevance of integrating BIM education aligned with progressive LOD requirements within architectural curricula. Educators and industry stakeholders can leverage these insights to tailor BIM training programs, curriculum development, and project-based learning experiences that align with industry standards and enhance students' preparedness for professional practice.

V. CONCLUSION

In summary, the data shows that participants acknowledge and link various advantages with Building Information Modeling (BIM). The diversity of perceived underscores the multifaceted impact that BIM can have across different aspects of the surveyed individuals' experiences. One key benefit highlighted in the data is the enhanced understanding facilitated by BIM through visualization. This suggests that respondents acknowledge the power of BIM in providing a clear and comprehensive representation of building information, aiding in better comprehension and decision-making processes.

The results of this study underscore the transformative capacity of BIM in improving the learning journey and equipping diploma students for real-world architectural endeavours. The overwhelmingly positive response from students regarding the impact of BIM on studio projects underscores its effectiveness in improving various aspects of architectural design and construction processes.

In conclusion, effectively incorporating BIM into architectural education for diploma students provides a route to equip upcoming architects with essential skills, tools, and mindset required to succeed in a swiftly changing industry landscape. By embracing BIM, educational institutions can bridge the gap between academic learning and industry practice, empowering students to create innovative, sustainable, and technologically advanced architectural solutions. Moving forward, continued research, collaboration with industry partners, and a proactive approach to curriculum development will further optimize the benefits of BIM implementation, ensuring that diploma-level architectural education remains at the forefront of transformative change in the built environment sector.

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