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Understanding BIM Adoption: A study of Usefulness, Ease of Use, and Attitude Among Malaysian Polytechnic Students

Nur-ul Balqes Md Zaid[1], Siti Haida Harris[2], Alvy Bartholomeus Philip[1]*
[1]Politeknik Kota Kinabalu, Civil Engineering Department, 88450 Kota Kinabalu, Malaysia.
[2]Politeknik Sultan Abdul Halim Muádzam Shah, Mathematics, Science and Computer Department, 06000 Kedah, Malaysia.

Abstract: This study investigates the willingness of polytechnic students in Malaysia to embrace and apply Building Information Modelling (BIM) in their learning and training. Although BIM is increasingly used in architecture and construction, there is a dearth of research focusing on students' attitudes regarding its application throughout their education. This gap in the literature is addressed by exploring the relationship between students' characteristics and their intention to utilize BIM, as well as the perceived usefulness and ease of use factors influencing this attitude towards using BIM. Using the Technology Acceptance Model (TAM) as a theoretical framework, the study analyses the perceptions of 418 civil engineering polytechnic students on perceived usefulness and perceived ease of use of BIM, indicating that these perceptions influence technology acceptance. Statistical Package for Social Sciences 20 (SPSS) and Smart PLS 4.0 were used to analyze data for this study. Findings indicate that students have a moderately positive attitude toward BIM usage. They perceive BIM as useful and easy to use, which indicates a positive disposition to incorporate it into their academic and future professional practices. These findings highlight the importance of incorporating BIM education into civil engineering curricula at polytechnics and higher education institutions in Malaysia. By enhancing BIM training, educators can foster positive attitudes and increase proficiency in BIM, facilitating its broader adoption in academic and industrial settings. Moreover, addressing students' attitudes regarding BIM application contributes to a deeper understanding of the factors influencing its adoption and integration into academic curricula and industrial practices.

Key words: *Building Information Modelling, perceived usefulness, perceived ease of use, attitude towards use, Technology Acceptance Model*

1.0 INTRODUCTION

1.1 Building Information Modelling (BIM)

Building Information Modeling (BIM) is a technique that has emerged as a result of the expansion of digital technology in the building sector (Walasek & Barszcz, 2017). BIM is one of the most recent construction industry methods, utilizing new technologies that are expanding throughout the world and have altered work processes and are utilized in planning, design, construction, and facility management (CITP, 2015; Aziz et al., 2016; Chen et al., 2018). One of the most important aspects of BIM is that it provides an object-oriented database comprised of 3D intelligent models with integrated information, as well as an interconnected relational database containing information developed by each industry participant (Walasek & Barszcz, 2017). BIM can also be referred to as a method of using digital technology for the development and integration of information centrally so that the information is more accessible, coordinated, transparent, and avoids disputes (Gu & London, 2010). Contractors and developers will no longer have to deal with the added time and expense that comes with these issues. National productivity will also rise as a result of the construction industry becoming more efficient, effective, flexible, and innovative (CITP, 2015; Gu & London, 2010; Xu, 2017).

Since the introduction of BIM technology, its importance has been acknowledged in all parts of the construction industry around the world. In particular, the value of BIM is highly regarded for large-scale and complicated projects (Xu, 2017). BIM is also known as the technology of the modern construction industry, and it is widely acknowledged as a key component of the catalyst for the Fourth Industrial Revolution, also known as Industry 4.0, which is currently gaining popularity (Oesterreich & Teuteberg, 2016; Xu, 2017). However, it is critical to recognize that BIM is not a goal in and of itself, but rather a means of achieving the aim of more efficient and productive project implementation while avoiding waste in terms of time, money, energy, and building materials (CITP, 2015; Walasek & Barszcz, 2017).

1.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model often known as the TAM, was originally used to examine user acceptance of technology in numerous studies of information-based systems (Venkatesh & Morris, 2000). TAM is a typical paradigm for studying technology acceptance that was developed on the Theory of Reasoned Action (Fishbein & Azjen, 1975; Ajzen & Fishbein, 1980). Davis, (1989) initially introduced TAM in his doctoral thesis. The model was soon changed (Davis, 1989). The original model and its revision were based on Theory of Reasoned Action (TRA) (Fishbein & Azjen, 1975).

The TAM model, which is the most prominent and is frequently used in technology acceptance studies, is frequently utilized in information technology acceptance (Lee & Lin, 2005). This is why TAM model were use in this study because it is the most influential model and is often used in the study of technology acceptance (G. Lee & Lin, 2005).This model's recommendations include variables that influence how and when people utilize them, as well as users who are presented with a new invention (Mohd Suki & Ramayah, 2010). According to (Davis, 1989), the TAM is a model that predicts consumer acceptance of technology based on two variables: perceived usefulness (PU) and usability (perceived ease of use, PEOU).

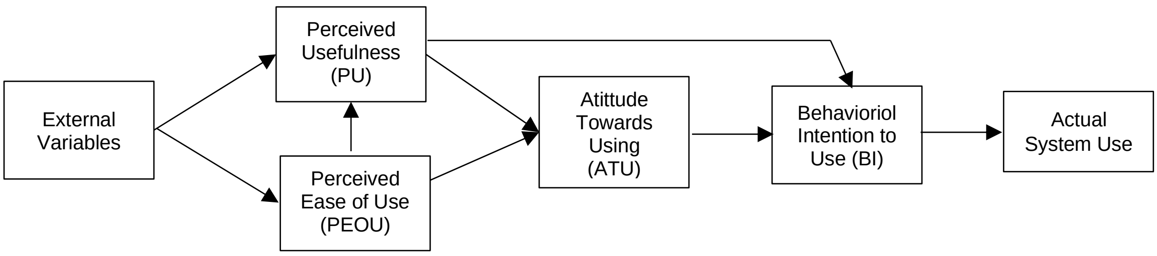

***Figure 1**: Technology Acceptance Model, TAM (Davis, 1989)*

1.2.1 Perceived Usefulness (PU)

PU can identify points of view on how attitudes toward technology influence consumer attitudes. In the TAM model, Davis (1989) refers to work productivity, performance, and effectiveness as PU. (Rogers et al., 2015) relative advantage of innovation traits is analogized to PU. In the context of BIM, polytechnic students in Malaysia may perceive BIM as useful if they believe it can streamline construction processes, improve project coordination, reduce errors, or enhance their learning experience. For instance, students may view BIM as beneficial for creating accurate 3D models, improving collaboration among project stakeholders, or aiding in design visualization.

1.2.2 Perceived Ease of Use (PEOU)

Rogers et al., (2015) compare PEOU to a perception or response to a distinguishing element of an innovation's complexity. It does not take much effort to investigate a PEOU innovation (Davis, 1989; Davis et al., 1989). In terms of conceptions and assessment scales, these PEOU performance objectives are identical (Venkatesh et al., 2003). In the case of BIM, polytechnic students' perception of its ease of use may depend on factors such as their prior experience with similar software tools, the availability of training and support resources, and the user interface design of the BIM software. If students find BIM intuitive, accessible, and conducive to their workflow, they are likely to perceive it as easy to use.

1.2.3 Attitude Towards Use (ATU)

The attitude toward use in the Technology Acceptance Model (TAM) is a key determinant of an individual's intention to use a technology. The model proposes that the user's attitude is influenced by two main factors: perceived ease of use and perceived usefulness. Research has shown that perceived ease of use has a direct effect on attitude towards use (Weng et al., 2018). The TAM predicts that attitude towards use, along with perceived usefulness, influences an individual's behavioral intention to use a technology, which in turn affects actual usage (Lederer et al., 1998). A positive attitude towards using BIM suggests that students are receptive to integrate BIM into their academic coursework, projects, or future careers in the construction industry.

1.3 The Integration of BIM into Education

The global construction industry's future is believed to be shaped by Building Information Modeling (BIM). As the need for BIM expertise rises, worry over the lack of BIM in tertiary education is spreading across the globe (Belayutham et al., 2018). Higher education institutions must incorporate BIM into their curricula so all graduates have the necessary skills and knowledge. The growth of AEC education is expected to be aided by the integration of BIM into higher education, which will also contribute to solving the limited supply of skilled BIM practitioners (Tanko Bruno Lot, 2022).

According to (Tanko Bruno Lot, 2022) because of BIM education, BIM-oriented graduates will emerge; thus, technical competency in BIM is a core competence that all graduates must learn, not an optional skill that adds value to a career. Despite having a common definition, we often observe that BIM is perceived differently by different individuals, which is the root cause of a failed collaboration culture. However, with the current increase of design complexity globally, it is urgently required to bring closer the academic collaboration of the disciplines involved in the design and construction process (Poerschke et al., 2019) for a common BIM ground to empower future graduates engaging in the AEC industry.

The future of AEC engineers plays an important role in establishing BIM as the only approach for processing building projects. Hence, it is imperative for educational institutions to modify their teaching methods in order to incorporate all aspects of BIM procedures across the whole lifespan of the product model. The AEC industry should use interdisciplinary measures to build a closed loop between AEC educational institutes, companies, and tool developers. This would ultimately result in enhanced overall performance and a greater impact on the building lifecycle (Rostam, 2019). Olowa et. al, 2020 found approaches that might assist in decision-making in BIM for construction education implementation in an institution by wide the level of engagement in the topics focused upon under different circumstances from the elementary introduction of BIM to more advanced conceptual teaching in a virtual BIM environment.

1.4 Polytechnic Malaysia

The establishment of technical and vocational schools initiated the establishment of polytechnics in this nation. It started in 1906 when the Treacher Technical School was established in Kuala Lumpur with the aim of training technicians for government technical departments. Practical subjects such as keeping balances, basket weaving, and carpentry began to be taught in several primary schools from 1920s (Shahril et. Al, 1999). In 1926, the first carpentry school was founded, offering basic courses to mechanics, electricians, and carpenters. Following independence, the government maintained its focus on technical education by establishing a dedicated technical education division within the Ministry of Education in 1964. This department is responsible for the process of planning and execution of all technical and vocational education initiatives in the nation (Kementerian Pelajaran Malaysia, 1970).

In 1969, the first polytechnic, Ungku Omar Polytechnic was established in Ipoh, Perak. Its establishment is the result of the recommendations of the Higher Education Planning Committee or also known as the Khir Johari Report in 1967. The establishment of this polytechnic aims to produce skilled workforce at the semi-professional level in the field of engineering and trade (Suffean Hussin, 2004). In addition, the lack of qualified technicians for companies enterprises and the lack of qualified staff to help with business affairs were also the impetus for the establishment of the polytechnic (Kementerian Pelajaran Malaysia, 1976). The first intake of Ungku Omar Polytechnic students in 1969 was a total of 290 people (Kementerian Pelajaran Malaysia, 1970). The courses offered at that time were Civil Engineering, Mechanical Engineering, Trade Courses and Business Studies. The qualification to enter the polytechnic at that time was to use the Malaysian Education Certificate.

The Building Information Modelling (BIM) course with the course code DCC50242 offered at polytechnics throughout Malaysia introduces the BIM process and 3D building modelling across the disciplines of architecture, structure, and Mechanical, Electrical, and Plumbing (MEP). One of the topics covered in this course is the basis of scheduling and coordination. The course aims to familiarize students with the fundamental concepts of BIM and its application in various aspects of building design and construction. The content includes an overview of BIM, industry trends in BIM adoption, and the BIM Project Execution Planning procedure, which encompasses scheduling and coordination aspects.

2.0 METHODOLOGY

This study uses quantitative methods to get an overview of the influence of the behavioural POEU and PU with ATU. The research process was carried out on Polytechnic students in Malaysia who had registered for the Diploma in Civil Engineering and Building Information Modelling (Building Information Modelling) subject for 14 weeks in session 1 2021/2022. The research employed original data collection through an online questionnaire. The instrument design incorporated reflective variables derived from Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Attitute Towards Using (ATU). The conceptual framework utilized in this investigation is illustrated in Figure 1.

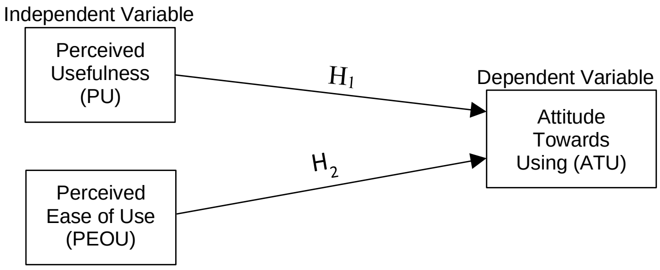

***Figure 2**: Conceptual Framework*

Data analysis using Partial Least Square Semantic Equation Model (PLS-SEM) by SmartPLS software version 4.0. The measurement model was tested using an outer model, while the structural model was tested using the inner model bootstrapping or resampling technique. Formulated from a conceptual framework and model, the hypotheses are as follows

H_1 = PU has a direct influence on ATU.

H_2 = POEU has a direct influence on ATU.

2.1 Instrument

The instrument utilized in this study was adapted from the one developed by (Davis, 1986) originally intended for users in the industry. Adjustments were implemented to suit the respondents who had an educational background and had used BIM as an instructional tool in the classroom. The survey comprised 19 items assessed using a five-point likert scale, with response options ranging from 1 (strongly disagree) to 5 (strongly agree). Table 1 shows some sample items for each of the variables. Prior to its use in this study, the instrument was content validated by experts from the field of education and technology. Experts in education and technology validated the instrument's content before it was used in this study. The instrument underwent pilot testing with a different group of students from Polytechnic Kota Kinabalu. Consequently, these students were excluded from the actual sample.

Table 1
A summary of the details of the questionnaire along with sources

Variable	Operational Definition	Total Item	Sources
Perceived usefulness (PU)	The recognition that the use of BIM is useful for improving the individual work ability and the productivity of collaboration.	5	(Davis, 1986)
Perceived Ease of use (PEOU)	Recognition that collaboration between organizational members using BIM is easy.	5	(Davis, 1986)
Attitude towards use (ATU)	Not only encourages the use of BIM among the student, but also the willingness to recommend it to other student in a cooperative relationship, and further, the willingness to participate in the development of BIM application technology.	2	(Davis, 1986)

3.0 DATA ANALYSIS AND FINDINGS

3.1 Respondents

The study's population consisted of all Polytechnic students in Malaysia who had enrolled in the Diploma of Civil Engineering and Building Information Modelling (Building Information Modelling) subject for 14 weeks in session 1 2021/2022. Throughout the duration of this study, there were around 1722 students enrolled in this program collectively. However, due to limitations related to time and cost, it was not feasible to gather data from every student within the target population. Consequently, a specimen was extracted from the accessible population in accordance with the approach proposed by (Krejcie & Morgan, 1970) the population of 1700 determining a sample size of 313. A total of 418 students completed the questionnaires, and it will be accepted. Table 2 presents the respondent demography.

Table 2
Respondent demographics across gender, age, and polytechnic affiliation (N=418)

Demography		Frequency (n)	Percentage (%)
Gender	Male/	224	53.6
	Female	194	46.4
Age	<18	0	0
	19-21	386	92.3
	>22	32	7.7

Polytechnic	Politeknik Ungku Omar (Politeknik Premier)	86	20.6
	Politeknik Port Dickson	54	12.9
	Politeknik Kota Bharu	45	10.8
	Politeknik Kota Kinabalu	40	9.6
	Politeknik Mukah Sarawak	33	7.9
	Politeknik Sultan Mizan Zainal Abidin	30	7.2
	Politeknik Sultan Haji Ahmad Shah	28	6.7
	Politeknik Melaka	26	6.2
	Politeknik Sultan Salahuddin Abdul Aziz Shah (Politeknik Premier)	19	4.5
	Politeknik Sultan Abdul Halim Mu'Adzam Shah	18	4.3
	Politeknik Merlimau	17	4.1
	Politeknik Kuching Sarawak	15	3.6
	Politeknik Sultan Idris Shah	4	1
	Politeknik Tuanku Sultanah Bahiyah	3	0.7

3.2 Outer Model-Measurement Model

Using the outer model technique, all indicators are tested by the standards of average variance extracted (AVE) of 0.5 or higher and validity findings over 0.7 for each construct (Hair et al., 2019). Reductions are made in order to attain covary because certain indicators are less equal than the overall outcome value of the indicator (Taber, 2018). Based on the reflective indicators' measurements shown in Figure 3. The range of 0.8 and 0.9 comprises the majority of indicators in the covary results that surpass 0.7, validating that all manifest variables possess suitable categories. The outcomes of each construct's validity and reliability tests are shown in Table 3. Displaying that the Average Variance Extracted (AVE) surpasses 0.5, and the reliability, assessed through Cronbach's Alpha, exceeds 0.6, alongside Composite Reliability exceeding 0.6 (Taber, 2018, J. F. Hair et al., 2019). The validity and reliability of all constructs are confirmed, as depicted in Table 3.

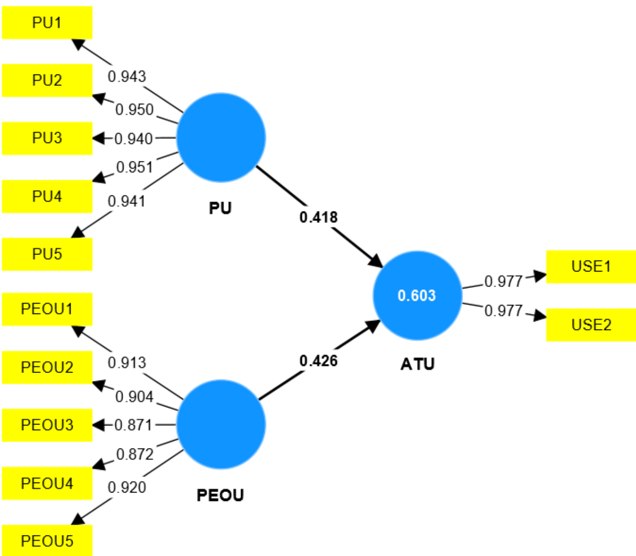

***Figure 3**: Outer Model Algorithm*

Table 3
Construct Reliability & Validity

Construct	rho_a	Composite Reliability	AVE	Cronbach's Alphas
Perceived usefulness (PU)	0.971	0.971	0.892	0.970
Perceived ease of use (PEOU)	0.954	0.954	0.804	0.940
Attitude towards use (ATU)	0.953	0.953	0.955	0.953

Table 4 illustrates Discriminant Validity by presenting cross-correlations among the examined constructs and other latent variables. These correlations should be smaller, as indicated by conditions comparing each construct with others based on the minimal AVE (Budhiasa, 2016). This approach ensures that each cross-correlation with latent variables remains valid for discriminant purposes.

Table 4
Discriminant Validity Fornell Larcker Criteria-Cross Correlations

	PEOU	PU	ATU
PEOU	0.896		
PU	0.692	0.945	
ATU	0.716	0.713	0.977

Heterotrait Monotrait (HTMT) is another outcome of the discriminant validity evaluation in Table 5.

Table 5
Discriminant Validity Heterotrait Monotrait (HTMT)

	PEOU	PU	ATU
PEOU			
PU	0.709		
ATU	0.741	0.741	

3.3 Inner Model–Structural Model

The inner model test evaluates the strength of the relationship between the constructs by examining the path coefficient using t-tests through bootstrapping or resampling. The criteria require a t-value > 1.65 for significance (one-tailed), 0.05 for two-tailed significance, and t > 1.96 for two-tailed significance. According to Hair et al., 2017), the path coefficient has a value in a range of -1 and 1, with a value approaching to 1 denoting a stronger positive significance and 0.1 with the top-value < 0.05. Test outcomes from the inner model are shown in Figure 3 and Table 6.

Table 6
Result of Inner Model Hypothetical

	Path Coefficient	t	P Values	Hypothesis
PEOU > ATU	0.426	6.604	0.000	H_2 Accepted
PU > ATU	0.418	6.197	0.000	H_1 Accepted

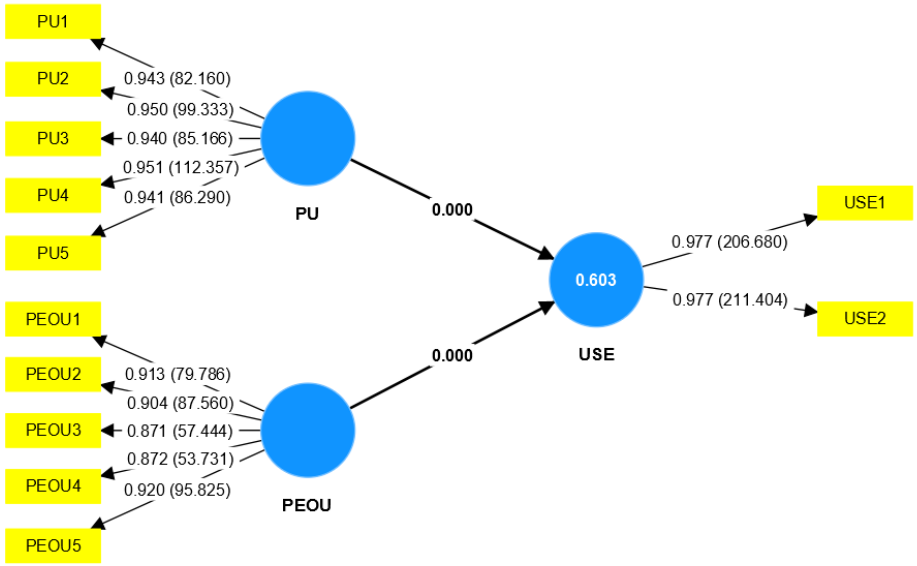

Figure 4*: Result of Inner Model Bootstrapping Resample*

In Table 6, the strongest value of perceived ease of use (0.426) and perceived usefulness (0.418) are positively correlated with actual use. Overall, the H1 and H2 hypotheses are accepted. Value coefficient determination (R^2) with result shown in Table 7 indicate of potential is 0.67 , an average value is 0.33, and weak is 0.19 (Chin, 1998). The attitude toward utilizing (ATU) of 0.603 indicates that ATU of 0.603 in the average category can be explained by the latent variable capacity of PU and POEU. When testing using f^2, a construct's effect with a criterion of 0.02 indicates a small effect size, 0.15 indicates a medium effect size, and 0.32 indicates a significant impact size. (Chin, 1998).

Table 7
Result of Inner Model R^2 Determination

	R^2	**Determination**
Atitude Towards Using (ATU)	0.603	Average

The findings suggest that the perceived ease of use moderately influences actual use, whereas perceived usefulness strongly influences both attitudes towards use and actual use. These results align with the theoretical significance of perceived usefulness (PU) and perceived ease of use (PEOU) that influence on user behavior within the Technology Acceptance Model (TAM) framework (Davis, 1989, Lederer et al., 1998). The findings support the idea that the ease of use and usefulness of a system significantly influence users' attitudes and behaviours towards its adoption and use.

Table 8
Result of Inner Model Construct Effect Size

	f^2	**Effect**
PEOU > ATU	0.239	Medium
PU > ATU	0.229	Medium

5.0 DISCUSSION AND CONCLUSIONS

The findings from the data analysis suggest that among polytechnic students in Malaysia, perceived ease of use exerts the most significant influence on their attitude towards using Building Information Modelling (BIM), followed by perceived usefulness. This result indicates that students' perceptions of how easy it is to use BIM software play a crucial role in shaping their overall attitude towards adopting and integrating BIM into their academic studies and future careers. If students find BIM intuitive, user-friendly, and accessible, they are more likely to feel good about using it. Ease of use may encompass factors such as the user interface design, availability of training and support resources, and prior experience with similar software tools.

Furthermore, the influence of perceived usefulness, while slightly less pronounced than perceived ease of use, remains significant. This suggests that students still consider the potential benefits and advantages of BIM technology in enhancing their performance, productivity, and learning experience. Perceived usefulness may include factors such as BIM's ability to improve project coordination, streamline construction processes, reduce errors, and facilitate collaboration among project stakeholders.

These findings underscore the importance of addressing students' concerns regarding the usability and practicality of BIM software in educational settings. Providing adequate training, support, and resources to enhance students' proficiency and confidence in using BIM can help cultivate a positive attitude towards its adoption and utilization. Additionally, highlighting the practical benefits and real-world applications of BIM technology can further reinforce its perceived usefulness among students, encouraging greater acceptance and integration into their academic coursework and future professional endeavours.

To investigate these constructs among polytechnic students in Malaysia, future researchers could conduct surveys or interviews to gather data on students' perceptions of BIM's usefulness and ease of use, as well as their attitudes towards using BIM in their studies and future careers. Statistical analyses, such as regression or structural equation modelling, could then be employed to examine the relationships between these constructs and identify factors that influence students' acceptance and adoption of BIM technology. Additionally, qualitative methods, such as thematic analysis, could be used to explore students' experiences, attitudes, and perceptions in more depth. Overall, understanding these factors is crucial for educators, policymakers, and industry professionals seeking to promote the effective integration of BIM into polytechnic education and training programs in Malaysia.

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