The Relationship between Building Information Modelling Skills and Employability of Architecture Graduates

Nor Azida binti Ishak, NurHidayah binti Azhar and Nadia binti Che Abd Rani

***Abstract* –The implementation of Building Information Modelling (BIM) in the Malaysian construction industry has been extensively studied by practitioners and academicians. However, the shortage of skilled manpower in this field persists despite the high demand in the industry. Firms seek graduates with skills to drive BIM as it requires collective efforts, thus, could increase the employability level of graduates with BIM skills. This study aims to assess the relationship between BIM skills and the employability of architecture graduates. To assess the objective, the level of BIM skills possessed by the graduates was identified upon completing the Malaysian diploma in polytechnic. A quantitative survey was employed with a finalised sample size of 169 graduates through random sampling from six Malaysian polytechnics that offer architecture courses. The collected data were analysed using the Statistical Package for Social Science (SPSS) to determine the descriptive mean, correlation, and multiple regression analysis. The results revealed a significant relationship between BIM skills and employability among architecture graduates ($p<0.05$). As for the assessment of BIM level among the graduates, a moderate level of BIM relative to industry needs was determined. These findings highlighted the need for architecture graduates to improve their BIM skills for an increased chance of employability due to industry demands. Identifying the skills necessary for fresh architecture graduates to be employed in the BIM construction industry is also essential. Hence, a collaboration between the academician (institution) and practitioner (industry) is required to specifically and continually determine the skills demanded in BIM. Such partnership may lead to a positive change towards curriculum improvement for polytechnic institutions and universities that offer architectural course.**

***Keywords* –Building Information Modelling, Employability, Technical Skills, Nontechnical Skills, Architecture**

I. INTRODUCTION

The concept of Building Information Modelling (BIM) was introduced by Professor Charles Eastman, who was affiliated with the Georgia Tech School of Architecture in the late 1970s (Ahmad-Latiffi et al., 2013). According to Azhar, Hein and Sketo (2008), the Architecture, Engineering and Construction (AEC) industry practically incorporated BIM in construction projects from the mid-2000s. BIM is generally adopted to increase productivity and efficiency (Othman et al., 2021) towards better project coordination.

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The private sector has led the implementation of BIM in Malaysia since 2009 (Haron, Raja Soh and Harun, 2017) before the government's intervention. Subsequently, the Malaysian government began strongly encouraging the construction industry to implement BIM in their projects due to its advantages in avoiding delays, design clashes, and reducing cost overruns (Kathi, Vasam, Rao and Rao, 2015). Subsequently, the Malaysian government-led institution, Construction Industry Development Board (CIDB) launched the Construction Information Transformation Plan 2016-2020 (CITP) program as part of a national program to ensure the growth and success of the Malaysian construction industry. Among the significant criteria listed by this plan is the utilisation of BIM Level-2 in line with the development of technology for digital construction (CIDB, 2019). The commencement of this plan encourages construction industry players to implement BIM into their construction projects. Moreover, the implementation of this plan aspires to increase the demand for a skilled workforce with BIM proficiency.

Despite the lingering demands, past literature revealed a few problems in the adoption of BIM among the workforce in the construction industry. According to a recent study (Kong, Lau, Wong and Phan, 2020), the greatest challenge lies in the poor training of the construction workforce to embrace BIM. Becerik et al. (2011) revealed a lack of adequately trained personnel to handle BIM. This statement was further supported by Jamal et al. (2019), who added that the available workforce is poorly skilled and less experienced in adopting BIM in the construction industry. There is also a concern about the security of data shared across the stakeholders with the possibility of unauthorised access and copyright (Ghaffarianhoseini et al., 2017). Besides that, the shift towards new collaboration approaches among stakeholders in the construction industry also remains a barrier to the adoption (Al-Ashmori, Othman and Al-Aidrous, 2022). Additionally, Sun et al. (2017) documented five main factors limiting the application of BIM in the construction industry, namely technology, cost, management, personnel, and legal. As for the personnel factor, they highlighted the importance of BIM education to improve the personnel's capabilities towards better adoption in future.

Adequate training during education level for the future workforce to embrace BIM could reduce these challenges. One of the approaches is to ensure that graduates from the AEC field are exposed to and educated about BIM during their tertiary education. Proper training can prepare the graduates to embrace new technology and upgrade their skills and knowledge during higher education (Majid, 2019), particularly for architectural graduates. The application of BIM in the construction industry improves productivity and collaboration (Ullah, Lill and Witt, 2019). Consequently, adequate training provides employers with future employees (graduates) who are proficient in BIM skills, knowledge, and experience. In short, an early introduction of BIM during the tertiary level can benefit students, employers, and organisations in producing a skilled workforce with BIM expertise. Hence, future graduates in the construction sector must equip themselves with BIM skills as part of the fundamental competencies for employability in the construction industry (Zhao et al., 2015).

II. PROBLEM STATEMENT

Job training is a significant factor in developing substantial human capital (Rosman et al., 2018). Human capital is essential in ensuring the construction industry's sustainability, as it is crucial in improving the organisation's performance (Rosman et al., 2018). Human capital refers to an individual's level of education, knowledge, and work competence (Aliu and Aigbavboa, 2019). A skilled workforce is needed to cater to the industry demands to support the development of a country. Therefore, the role of higher educational institutions is crucial in producing graduates with skills and knowledge to meet the industry demands, in this case, the construction industry. The job market for the construction industry places higher demands for employees proficient in BIM (Mojtaba and Ku, 2010; Dare-Abel et al., 2014).

The need for graduates-proficiency with BIM versus employers' demands in the construction industry is justified by assessing the relationship between BIM skills and employability of architecture graduates from polytechnic. In addition, this study also identified the level of BIM skills acquired by graduates which is beneficial for BIM-curriculum enhancement. The employability level was also assessed to determine the chance of graduates being employed and supported by employers based on their BIM skills.

III. LITERATURE REVIEW

BIM Skills among Graduates

Technology BIM is acknowledged as a concept that could transform the construction industry globally (Doan et al., 2019). The delivery of construction projects proved to be efficient with the integration of BIM. Hence, BIM skills and knowledge are essential to ensure that individuals understand BIM's use, function, and operation. Most employers demand employees equipped with BIM knowledge and skills and those who know to use and operate BIM software (Mojtaba and Ku, 2010). Thus, graduates should be equipped with BIM skills to improve their chances for fast employment. Furthermore, Kugbeadjor et al. (2015) posited that BIM education is necessary during higher education so that students have deep knowledge and skills to succeed in the BIM construction industry. The early introduction of BIM education provides graduates with the awareness of the importance and readiness to implement BIM knowledge and skills in the future.

On the other hand, it is also claimed that the chance of employment among AEC graduates is linked to BIM skills. Previous studies reported that employees with BIM skills are more likely to be successful in their jobs than those who only develop technical skills (Haron et al., 2019). Employers are very selective in choosing new employees, especially fresh graduates because there is a higher cost incurred in replacing a skilled employee in a firm (Muehlemann and Strupler Leiser, 2018). In short, BIM skills benefit graduates with a higher chance of employment. Employers prefer graduates with deep conceptual knowledge and skills (Abdullah, 2012; Ang, 2015; Ooi and Ting, 2015; Hanapi et al., 2018; Kamaruzaman et al., 2019; Shekhawat, 2020).

Graduate Employability

Graduates must have the ability to become competent employees (Govender and Wait, 2017). They must have skills, knowledge, experience, and attitudes to meet the employer's demands and enable them to perform by utilising their skills and knowledge. Those skills need to be developed during tertiary education to become employable and fulfil the industry's needs. Hanapi et al. (2018) further added that graduates who are equipped with the skills and knowledge are easily employed.

Graduate employability is the individual's ability to obtain a job after completing their study (Harvey, 2003). While Romgens, Scoupe and Beausaert (2020) relate employability as a competence-based dimension which emphasises the identification and development of knowledge, competencies, and attributes that facilitate students' development towards efficacious accomplishment in the working field. Certain academic institutions provide employability programs to their graduates to ensure that they are employed within 6 to 12 months after completing their studies. Higher educational institutions are responsible for ensuring that their graduates are equipped with the skills and knowledge per the industry's professional requirements. Due to a lack of preparation in professional practice during their tertiary education (Knight and Yorke, 2004), graduate employability has become a challenge (Small, Shacklock and Marchant, 2018). Therefore, the graduate employability program was an essential platform for developing quality workers for a productive labour market. Many programs were also developed to identify the status of graduates upon graduation and ensure quality labour was produced (Aida et al., 2015).

This study defines employability level as the chance of employment and employee support as perceived by the graduates. Graduate employability is potentially linked with the embedded BIM skills and knowledge acquired during their study course, especially for architecture graduates. Zhao et al. (2015) and Ismail et al. (2019) reported that graduates with BIM skills and construction technical skills (Autodesk Revit, AutoCAD, etc.) could benefit from the chance of being employed as the skills were demanded and expected by the industry.

IV. METHOD

This study aims to determine the relationship between BIM skills and graduate employability among architecture graduates from Malaysian polytechnic institutions. This study also identified the level of BIM skills (technical and non-technical) acquired by architecture graduates. To assess these aims, the current study conducted a quantitative methodology for data collection and analyses. Data collection incorporated a survey questionnaire which was developed through literature reviews.

The study sample comprised graduates from the Diploma program in architecture at Malaysian polytechnic institutions. These graduates were selected because they have less than a year of working experience, learned a BIM course during their studies, and were employed upon graduation. A total of 169 graduates were finalised through simple random sampling. The questionnaires were distributed to the graduates using google form through email.

There were three main sections in the survey questionnaire: Section A, B, and C. Section A consisted of information on respondents' demographic profiles. In contrast, Section B measured the respondent's BIM skills after graduating from the polytechnic. An example of an item in Section B is, "I am able to seek and share information with colleagues on new skills and technology on BIM". Whereas Section C measured the employability of graduates after getting a job which has items such as, "My company allows me to meet challenges in the work". Generally, 10 constructs were developed through the literature review: computer application skills, construction technology skills, modelling skills, virtual modelling skills, design skills, communication skills, willingness to learn, teamwork, creativity, and problem-solving skills. Each construct comprised five items as a measurement requirement, as displayed in Table 1.

TABLE I: DISTRIBUTION OF QUESTIONNAIRE ITEMS.

No	Construct	Items	Total
		Section A	
	Demographic Profiles	Gender, Employment status, CGPA, Polytechnic	4
		Section B	
1	BIM Skills	Modelling Skills, Virtual Modelling Skills, Design Skills, Construction Drawing Skills, Computer Application Skills, Communication Skills, Willing to Learn, Problem-solving Skills, Teamwork Skills, Creative Skills	50
		Section C	
3	Employability	Employability of Graduates	6

The data obtained from the questionnaire were analysed using IBM Statistical Package for Social Science (SPSS) version 25.0. The relationship interpretations were performed using the *Rules of thumbs* (Mukaka, 2012).

V. FINDINGS

The descriptive statistics of the architecture graduates were explored in terms of frequencies and percentages for the Section A of the questionnaire. As for Sections B and C, the descriptive statistics were analysed using the means and standard deviations, where inferential statistics were used to determine the relationship and gender differences. Table 2 displays the total number and percentage of respondents according to gender, CGPA, and employment status of graduates from the Malaysian polytechnics.

TABLE 2. RESPONDENT DEMOGRAPHICS PROFILES.

Profiles	Frequency	Percent%
Gender		
Male	85	50.3
Female	84	49.7
Employment Status		
Full-time Job	103	61
Contract Worker	66	39
CGPA		
2.00 – 2.44	2	1.2
2.45 – 2.99	65	38.5
3.00 – 3.49	86	50.9
3.50 – 4.00	16	9.5
POLYTECHNICS		
Politeknik Ungku Omar	36	21.3
Politeknik Sultan Haji Ahmad Shah	28	16.6
Politeknik Sultan Abdul Halim Muadazam Shah	34	20.1
Politeknik Port Dickson	21	12.4
Politeknik Merlimay	30	17.8
Politeknik Sultan Idris Shah	20	11.8
Total	**169**	**100**

Male (50.3%) and female (49.7%) graduates were almost equal to the total sample size. Most of the graduates were full-time workers (61 %), while the remaining were on contract (39%). More than 50% of the graduates scored a CGPA of above 3.00. The sample size from each polytechnic was based on the intake for each institution as shown in Table 2. The highest number of graduate samples were recruited from PUO polytechnic (21.3%). However, the percentage of the sample representing each polytechnic was almost equal, validating the reliability by providing robust analytical results.

Analysis of the Level of BIM Skills among Architecture Graduates

Table 3 identifies the level of BIM skills among architecture graduates. The BIM skills were measured using 10 constructs (computer application skills, construction technology skills, modelling skills, virtual modelling skills, design skills, communication skills, willingness to learn, problem-solving, teamwork, and creativity). These constructs were adapted from previous literature. Based on descriptive mean and standard deviation analyses, the teamwork construct yielded the highest mean score ((M=3.92, SD=0.767) compared to the other constructs. While willingness to learn construct recorded the lowest values (M=3.27, SD=0.688). As for the different constructs, they yielded mean scores between 3.71 and 3.49. Based on Landell's (1977) categorisation of mean scores, three of the constructs have a high mean score: teamwork, design, and problem-solving Skills. The other seven constructs fell within the moderate level of the mean score. The results were interpreted to reveal that the graduates perceived themselves to have higher BIM skills in the context of teamwork, followed by design skills and problem-solving. However, they also agreed that they are less willing to learn. Since the overall mean score (3.60) for all constructs combined yielded an average mean score (Landell, 1977), it can be deduced that the general BIM skills for graduates were moderate.

TABLE 3. LEVEL OF TECHNICAL SKILLS IN BIM.

No	Constructs	Means	SD	Level of Mean Score *(Source: Landell, 1977)*	Overall Means
1	Teamwork Skills (TS)	3.92	.767	High	3.60 *(Moderate Level based on Landell, 1977)*
2	Design Skills (DS)	3.71	.730		
3	Problem-solving Skills (PSS)	3.69	.800		
4	Communication Skills (COM)	3.60	.570	Moderate	
5	Creative Skills (CS)	3.56	.828		
6	Construction Technology Skills (CTS)	3.53	.650		
7	Modelling Skills (MS)	3.51	.884		
8	Computer Application Skills (CAS)	3.49	.716		
9	Virtual Modelling Skills (VMS)	3.49	.719		
10	Willingness to Learn (WTL)	3.47	.688		

Analysis of Graduate Employability

Table 4 presents the results for graduate employability. The descriptive mean and standard deviation analyses were used to analyse graduate employability. The results indicated that a higher mean score was recorded for Graduate Employability (EMP) (M=3.70, SD=0.679), suggesting that the graduates perceived themselves to have a higher level of employability.

TABLE 4. LEVEL OF EMPLOYABILITY

Construct	Means	SD	Level
Graduate Employability (EMP)	3.70	.679	High

Relationship between BIM Skills and Employability

Pearson's correlation was employed to determine the relationships among the study variables by selecting the significant variables through the p-value of less than 0.05 to allow the rejection of null hypotheses. Table 5 lists the results of correlations. The results indicated that all constructs in BIM skills (modelling, virtual modelling, design, computer application, construction technology, communication, willingness to learn, problem-solving, teamwork, and creative skills) possessed a significant and positive relationship with employability. However, the relationships lay between moderate and weak positive relationships.

According to Table 5, the correlations between creative skills (r=0.504; p=0.000, p<0.05) and modelling skills (r=0.501; p=0.000, p<0.05) were statistically significant, with a moderate positive relationship with employability. Comparatively, computer application skills (r=0.281; p=0.001, p<0.05) were statistically significant, with employability with a fragile positive relationship.

Meanwhile, virtual modelling skills (r=0.482; p=0.000, p<0.05), design skills (r=0.382; p=0.000, p<0.05), construction technology skills (r=0.427; p=0.000, p<0.05), communication skills (r=0.367; p=0.000, p<0.05), willingness to learn (r=0.494; p=0.000, p<0.05), problem-solving skills (r=0.484; p=0.000, p<0.05), and teamwork skills (r=0.405; p=0.000, p<0.05) were statistically significant with employability with a weak positive relationship to employability.

TABLE 5. PEARSON'S CORRELATION BETWEEN BIM SKILLS AND EMPLOYABILITY

Construct	1	2	3	4	5	6	7	8	9	10	11
Modelling Skills	1										
Virtual Modelling Skills	.692**	1									
Design Skills	.625**	.685**	1								
Computer Application Skills	.536**	.554**	.479**	1							
Construction Technology Skills	.623**	.658**	.548**	.378**	1						
Communication Skills	.519**	.431**	.458**	.330**	.388**	1					
Willingness to Learn	.534**	.434**	.456**	.328**	.436**	.393**	1				
Problem-solving Skills	.518**	.492**	.520**	.378**	.436**	.539**	.543**	1			
Teamwork Skills	.516**	.448**	.490**	.331**	.355**	.506**	.474**	.648**	1		
Creative Skills	.569**	.548**	.548**	.443**	.483**	.515**	.624**	.618**	.638**	1	
Employability (EMP)	.501**	.482**	.382**	.281**	.427**	.367**	.494**	.484**	.405**	.504**	1

** *Correlation is significant at the level 0.01 (2-tailed)*

Table 6 displays the result of the hypotheses testing for the study. Although the variables were significant, they had a relationship with the dependent variables, thus, supporting the hypotheses.

TABLE 6. HYPOTHESES TESTING RESULTS.

Hypotheses	Standard Path Coefficients	Significance	Relationship Strength	Support
H1: MS→EMP	0.501	0.000	Moderate positive	Yes
H2: VMS→EMP	0.482	0.000	Weak positive	Yes
H3: DS→EMP	0.382	0.000	Weak positive	Yes
H4: CAS→EMP	0.281	0.000	Very week positive	Yes
H5: CTS→EMP	0.427	0.000	Weak positive	Yes

H6: COM→EMP	0.367	0.000	Weak positive	Yes
H7: WTL→EMP	0.494	0.000	Weak positive	Yes
H8: PSS→EMP	0.484	0.000	Weak positive	Yes
H9: TS→EMP	0.405	0.000	Weak positive	Yes
H10: CS →EMP	0.504	0.000	Moderate positive	Yes

Multiple regression was also conducted to determine the best linear combination of BIM skills and employability to predict their contribution towards increasing the employability of architecture students who graduated from Malaysian polytechnics. Table 7 summarises the multiple linear regression analysis using the Beta weight coefficients. The results revealed that two constructs, namely virtual modelling and willingness to learn contributed the most to predicting graduate employability. The R^2 value of .39 indicated that the model explained 39% of the variance in graduate employability. In short, 39% of the variance in variable graduate employability can be predicted from the combination of 10 constructs of independent variables in the model. This value is considered a large effect (Cohen, 1988) thus, it has practical significance.

TABLE 7. MULTIPLE LINEAR REGRESSION ANALYSIS RESULTS.

Multilinear regression analysis summary for predicting employability from a combination of the constructs					
	B	**SE**	**Beta**	**t**	**p**
1 (Constant)	1.342	.367		3.662	.000
Modelling Skills	.132	.082	.167	1.616	.108
Virtual Modelling Skills	.203	.102	.209	1.990	.048
Design Skills	-.103	.090	-.107	-1.139	.257
Computer Application Skills	-.079	.077	-.081	-1.025	.307
Construction Technology Skills	.050	.097	.047	.520	.603
Communication Skills	.021	.098	.017	.212	.832
Willingness to Learn	.190	.086	.187	2.196	.030
Problem-solving Skills	.149	.085	.171	1.758	.081
Teamwork Skills	-.019	.087	-.021	-.219	.827
Creative Skills	.126	.084	.149	1.500	.136
F-value		**10.028**			
Sig.		**.000**			
Adjusted R^2		**.350**			
R^2		**.388**			

Note: $R = .623$; $R^2 = .388$; adjusted $R^2 = .350$; $F(10, 158) = 10.028$, $p = 0.000 < 0.001$

The model of multiple regression was statistically significant ($R^2 = .350$, $F[10,158] = 10.028$, $p = 0.000 < .001$), with 39% of the variance in employability. The two significant constructs which largely contributed to the variance of graduate employability were virtual modelling ($B = .203$, $\beta = .209$, $p = .048$) and willingness to learn ($B = .190$, $\beta = .187$, $p = .030$). Contrarily, the other constructs were not statistically significant.

In conclusion, the results suggested that virtual modelling and willingness to learn contributed the most to graduate employability in the BIM construction industry.

VI. DISCUSSION

The statistical result (mean and standard deviation analyses) on graduate employability implied that most of the architecture graduates from the polytechnics were able to land a job upon graduation which coincides with their moderate BIM-skills level. According to Awang et al. (2012), most graduates can be employed if they have the relevant skills demanded by the industry. Moreover, Hanapi et al. (2014) reported that skills among graduates influenced their employment status. Employers prefer graduates with deep conceptual knowledge and skills necessary for graduates to enhance their technical skills. This finding provides empirical evidence and emphasises the importance of graduates acquiring BIM skills from higher education to ensure their recruitment upon graduation.

The overall BIM skills of the graduates were moderate, which is in line with another study (Siti Husain et al., 2017) which identified an average level of BIM skills among technical graduates. Graduates also perceived themselves to possess higher BIM skills in teamwork, design, and problem-solving. In the construction industry, teamwork is essential because there is a need for members of the team to establish a good working relationship to promote better project performance (Adu and Opawole, 2020; Koolwijk, Oel, and Moreno, 2020.

Design skills are also substantial for a member of the construction industry (Deepa and Seth, 2013), while problem-solving skills were cited as a crucial trait in improving construction project performance (Alshammari, Yahya and Haron, 2020). Hence, individuals in the AEC workforce must be skilled in operating BIM software tools and other design tools (Syed Fadzil, Taib and Ishak, 2021). Graduates with good design and problem-solving skills are regarded as competent workers to propose and implement designs during the entire construction project.

The regression analysis suggested that virtual modelling and willingness to learn were the two significant contributors to the employability of graduates. This result was also supported by Eldeen et al. (2018), who listed tool handling competency as one of the skillsets demanded by employers in Malaysia. This demand was relevant due to the heavy dependency on different tool software to accommodate project delivery in the construction industry. According to Majid et al. (2012), willingness to learn is one of the essential skills for employment. Soft skills are essential for graduates to ensure employability and improve their performance upon hire.

VII. CONCLUSION

Construction firms need to engage in BIM for future workforce planning (Wu and Issa, 2014). According to Othman et al. (2021), BIM implementation in Malaysia concerning private and public construction sectors is still at the beginning level. Therefore, pre-knowledge and skills should be incorporated into the tertiary education system to increase its adoption.

This study assessed the relationships between BIM skills and employability among polytechnic architecture graduates. The results revealed that the graduates perceived themselves to have a moderate level of BIM skills and higher employability upon graduation, in line with the construction industry demands requiring employees proficient in BIM (Mojtaba and Ku, 2010). This study provided empirical evidence on the importance of BIM preparedness during tertiary education to equip themselves for a better chance of employability.

This study also discovered a positive relationship between graduates' BIM skills (virtual modelling and willingness to learn) and their employability level. Hence, indicating that there is a valid argument linking BIM skills and employability.

To cater to the industry needs, the institutions and industry need to work together to ensure graduates are equipped with the skills to develop their careers (Hanapi et al., 2014). The collaboration could also ensure that the output of semi-skilled workers from higher institutions meets the demands of the industry (Abdullah, 2012; Lee and Yun, 2015). Therefore, tertiary institutions should supply additional BIM-related knowledge courses to architecture students to meet industry demands. This step would benefit the construction industry as it would have competent workers to navigate with BIM skills in construction projects. BIM-competent employees can ensure a better workflow and project delivery.

VIII. LIMITATION OR SUGGESTION FOR FURTHER STUDIES

A few limitations limit the findings of this study. Firstly, the gathered data is limited to graduates from architecture programmes in Malaysian polytechnics. The architecture program is diploma-based and most syllabi taught are within its set subject frame. Hence, future studies could expand this study by involving graduates from a degree (Bachelor's) level, which may generate different results than the current outcome.

Secondly, this study was conducted within the geographical location of Malaysia, hence, limiting the generalisation to other countries. Malaysia has different economic and social perspectives due to the presence of various races. Thus, it limits the interpretation of data through the conducted analyses. It is recommended to explore the possibilities of a similar framework in other countries especially developed countries such as the United States of America, Japan, or China.

The overall study could be more comprehensive if it was conducted using focus group discussions among experts in BIM construction to identify the precise industry demands towards fresh graduates. Moreover, a larger sample population should be recruited, including university graduates, to help identify the differences in the required BIM skills between diploma and degree graduates.

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