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Abstract— **Building Information Modelling (BIM) education is gaining more attention from various parties such as government, industry, and academicians. Many universities have integrated BIM into their curricula by using various approaches and teaching methods, but there is no commonly accepted approach to teaching BIM in Architecture, Engineering, and Construction (AEC) programs. This research aims to identify the level of BIM literacy among students in higher education institutions and its correlation with the components of BIM learning and the outcomes of BIM learning progress. A quantitative method was adopted where Partial Least Square – Structural Equation Modeling (PLS-SEM) analysis was used to analyze the data. Questionnaires were distributed to the respondents for data collection. A total of 33 respondents were chosen, consisting of second-year undergraduate Construction Management students at Universiti Sains Malaysia. The results were analyzed by using SPSS and SmartPLS 3. SPSS was used to study the correlation between variables, whereas SmartPLS was used to conduct other tests such as the path coefficient, bootstrapping, coefficient of determination (R-squared), effect size (F-squared), collinearity statistics (VIF), inner and outer VIF value, outer loading and outer weights. From the result findings, it was found that the respondents have less knowledge of the BIM software. The respondents also felt neutral toward improving their CGPA through BIM courses. Results showed that 3D parametric modeling and outcomes of BIM learning are correlated. For future research, the focus can be shifted to other BIM competencies, such as the managerial, functional, technical, and support aspects of BIM.**

Keywords— **Digital technology fluency; BIM learning environment; undergraduate; construction management; competency.**

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I. Introduction

The implementation of Building Information Modeling (BIM) in the construction industry is getting significant [1], [2], [3]. Although the BIM adoption progress is slow surely, BIM is gaining more attention every year in the construction industry [4], [5]. BIM is known as a data tool used in engineering design, construction, and management, where it is the second revolution in the construction industry [6]. Ferrer-Estévez and Chalmeta [7] stated that since BIM is gaining wide acceptance and recognition in the construction professionals worldwide, especially those who are from the Architecture, Engineering, and Construction (AEC)'s field, are facing a new transition from the old technology to BIM [8], [9], [10]. To be precise, BIM competencies include the processes such as procuring, producing, using, and maintaining BIM-specific deliverables that include the 3D models and data to design, construct and operate in the life cycle [8], [11], [12]. This is to cater to the demands of the industry for talents with relevant skills where the academic institutions are seeking ways to integrate BIM learning in undergraduate curricula [13], [14]. Ao et al. [13] also mentioned that there are some approaches to learning and improving BIM competencies via formal education, in-house training, and professional development in improving one's traits.

The study of the nexus of BIM between education and industry started to gain more intention as the outcomes helped to improve the productivity of the AEC industry in terms of environmental, economic, social, and operational performances [7], [15], [16]. Several studies have been carried out where Becerik-Gerber et al. [17] studied 101 university-level AEC programs that considered the challenges in merging BIM into their courses, Sacks and Pikas [18] investigated the gaps in BIM content in tertiary education among leading universities and industry requirements and Wang, et al. [19] who studied about the technical and managerial aspects of BIM in the interdisciplinary collaborations. Furthermore, Caroline Clevenger [20]'s research studied the opinions of 113 students who incorporated BIM into their curricula. 62% of the students suggested having a standalone BIM class and adding BIM modules to the existing subjects, which can introduce BIM concepts and software to the students. These students also suggested that they should be taught about higher BIM modules. This is to increase their understanding on how BIM can improve various factors of construction management and keep them updated with the latest BIM software throughout university learning [9], [21]. In the study, the researchers created contents of each teaching module to expose the core construction concepts while showcasing leading industry best practices [22], [23]. At the end of the result, the module could engage a high level of spatial cognition and critical thinking among the students with its interactive and visual nature.

The main idea of this study highlights that the relationship between digital technology and BIM is interrelated [24], [25], [26]. Students from tertiary education institutions need to master both theories and digital skills during their undergraduate study, where BIM is emphasized as part of information technology [3], [7], [27]. Thus, the rationale of this study is to identify students' digital literacy, how digital literacy could help them learn BIM, its correlation with BIM learning components, and the outcomes of BIM learning.

- What is the literacy level of students in using digital & BIM technology?
- Which digital literacy element has the highest impact on BIM learning components?
- Do digital literacy and BIM learning component affect the outcomes of BIM learning progress?

II. Materials and Methods

In this decade, being digitally competent is very important [8], [11], [12]. When digital competence is mentioned, technology could first come to mind. Many terms are created to describe the skills and competence of using technology and digital, such as ICT skills, information technology (IT) skills, information literacy, and digital literacy. Since the world is more digital-oriented, where digital and technology usage is a part of our daily lives, it is vital for everyone, especially the younger generation, to be digital literate. It is important for educators to take up their roles in teaching and educating students to learn the basics of digital usage in schools [3]. Moreover, since BIM has been obtaining wide acceptance and recognition in the AEC industry, the experts in the industry has faced challenges in the transition from 2D computer-aided design (CAD) to 3D BIM [8], [28]. Thus, tertiary learning institutions are exploring strategies to incorporate BIM education in their undergraduate curricula.

Several concepts related to Digital Competencies are as follows:

1) Digital Literacy: One of the concepts of digital competencies is digital literacy. Vidosavljevic and Vidosavljevic [29] defined digital literacy as the ability of a person to perform a task in an information society. Digital literacy literally means the ability to read and interpret technology and capable of applying new knowledge learned from the digital environment [27], [30], [31]. Digital literacy in this day also includes decoding and encoding digital texts.

2) ICT Skills: Turk [32] defined ICT skills as the knowledge that allows communities to participate within a networked society. Computer or ICT literacy is the skills students require to operate various computer applications, such as word processing, databases, and spreadsheets [33]. Furthermore, there are Information Technology (IT) skills such as copying disks and generating hard copy printouts [32]. It is the skills to know how to use a computer and relevant software [30], [33], [34].

3) Internet Skills: Internet skills refers to the competency of using network resources, media, and communications. Turk [32] mentioned that internet skills should include the basic components of digital literacy. This knowledge is the understanding of the role and uses of networked resources, while the necessary skills refer to the capability to use networked resources for work and personal [3], [35], [36].

4) Information Literacy: Information literacy refers to the identification, location, evaluation, and use of media materials [3]. In this context, information literacy means that information is easily accessed digitally for all. This day, it is more beneficial for those who are information literate than those who do not [12], [35].

Nowadays, various BIM software in the industry cater to different aspects of design and construction activities [19]. BIM software can help architects and designers plan the building model using Bentley Architecture, allowing contractors to stimulate the construction projects using Vivo Office Suit. With the advent of mobile technology, BIM software is also designed as mobile apps for mobile phones and gadgets. For example, an app called PlanGrid allows the update and sharing of blueprints and technical drawings among stakeholders [37]. New technologies, such as mobile applications for BIM, can improve efficiency and increase productivity while lowering project costs and mistakes [38]. In Olowa et al. [39]'s survey, the results showed that participants prefer to hire students who have BIM skills.

ICT's importance in all fields is growing, including construction and education [11]. This is due to the rapid development of mobile phones, tablets, laptops, and desktops, which ease information sharing and improve productivity [40]. Therefore, the competencies pertinent to using ICT are now highly required by employers [41]. To fulfill the market's demands, education tertiary education institutions have considered developing these capabilities as the priority in teaching policies. Since the construction industry is well known as reluctant to change, conservative, and highly fragmented, which raises many barriers to the incorporation of new technologies, education is the best tool to overcome these entry barriers [42], [43]. Adopting BIM technology in universities' courses could help catalyst the implementation of BIM in the construction industry [11], [42]. Thus, digital literacy, ICT skills, internet skills, and information literacy are emphasized in this study as the core knowledge that undergraduate students should master.

Construction projects involve various activities that need proper planning and execution capability to construct the building successfully [38]. Incorporating BIM in construction management courses could help students understand the construction processes [3]. However, BIM is not simply a new software that can stand-alone to support the entire construction project. Therefore, students need to understand how the BIM streamlines the collaboration process of a construction project, as this is much more important that mastering the software solely [12]. Furthermore, recent studies have suggested a shift in BIM education from technology-centric to process-centric, emphasizing project execution-oriented BIM competency. Therefore, the emphasis should be on the students' self-directed learning ability as the evolution speed of information technology is incredibly fast. Although students need soft skills such as collaboration, communication, teamwork, and leadership, the digital literacy and BIM learning environment have been proven to improve the learning progress among students as BIM components help the students to understand complicated construction projects easier [3], [8], [11], [12].

To reach the full potential of BIM education, there should be considerable effort in implementing BIM. To successfully implement BIM, teaching BIM competencies to students during tertiary education is important before graduating [7]. Null hypothesis is needed to analyze the variables using SmartPLS 3. Therefore, the null hypothesis formed in this study are:

- H_1: 2D digital interpretation significantly contributes to 3D parametric modeling.
- H_2: 2D digital interpretation significantly contributes to the outcome of BIM learning in class.
- H_3: 3D parametric modeling significantly contributes to the outcome of BIM learning in class.
- H_4: Both 2D digital interpretation and 3D parametric modeling significantly contribute to the outcome of BIM learning.

A quantitative method was used in this research. This approach showed the level of experience and knowledge of the respondents. Information was gathered from both primary and secondary sources. Primary sources include the information obtained using a questionnaire survey, while secondary sources include published research papers, articles, journals, and books. The method of data collection is to collect data via a questionnaire survey. Clustered sampling method was used, where subgroups of the students are used as the sampling unit rather than individuals.

Questionnaire surveys were used to collect information from the targeted respondents, and convenient sampling was used to target the relevant respondents. After collecting data from the targeted respondents, the data was analyzed using quantitative software such as the SPSS and SmartPLS 3 and the results were compared with the literature review in the discussion session. Next, the data analysis was checked to determine whether it answered the aims and objectives.

The questionnaire aims to identify the level of digital literacy among students in higher education institutions, its correlation to the components of BIM learning, and the overall academic performance are divided into three sections. The first section identifies the respondents' background, such as their age, gender, highest level of qualification, CGPA in the last semester, and grades in relevant subjects. The second section determines respondents' digital literacy level by identifying the level of problem-solving skills, communication and collaboration skills, operation and information creation skills, information processing skills, support, and data security and safety skills. The third section aims to explore the level of BIM competence of respondents in terms of their level of interpreting basic construction drawings, managerial competence, functional competence, technical competence, supportive competence, and the outcomes from the digital and BIM learning in class.

TABLE I
COMPONENTS OF COLLABORATIVE BIM EDUCATION FRAMEWORK

No.	Component	Brief description
A	Identifying BIM competencies	BIM competencies are a combination of BIM skills (practical knowledge), experience, and conceptual knowledge to perform a BIM-related task. Examples of BIM competencies include understanding typical BIM collaboration workflows, the legal implications of using models as the primary source of design information, and developing and managing object libraries
B	Classifying BIM competencies	This component highlights how BIM competencies should be consistently defined by developing a BIM dictionary to unify terms; a taxonomy to organize competencies; and a faceted classification (e.g., roles, disciplines, difficulty levels, and delivery methods) to filter competencies according to target audiences
C	Developing BIM learning modules	This component advocates an online BIM learning hub with a database of competency items. The database serves as a knowledge source for developing BIM learning modules and learning material to fulfill varied educational requirements
D	Developing an industry framework for professional development	This component advocates the development of a BIM education cooperation framework between industry associations to allow the generation and joint-delivery of collaborative BIM learning modules and BIM learning material
E	Developing or adopting an academic framework	This component highlights the need for developing or adopting 1 a specialized academic framework for BIM education to enable academic institutions to contribute to and benefit from the BIM learning hub
F	Initiating a BIM institute	This component highlights the need for a dedicated organizational structure - a national BIM institute – to facilitate and promote BIM learning across industry

The question structure consists of rating-scale questions, which is Likert-type scales. Respondents are given five choices to show how strongly they agree or disagree with the questions. It ranges from "strong disagree", "disagree", "neutral", "agree", to "strongly agree". The implementation of Likert-type scale in questions is better as it gives more precise answers compared to the dichotomous-styled answers, and the results are far easier to be compiled.

The sample population consists of second-year Construction Management students at Universiti Sains Malaysia (USM). These students are chosen as they have gone through digital literacy and some BIM classes, such as Glodon

Cubicost. Although the sample size is small, it is still able to answer the objectives, as the overall complexity of a structural model has little influence on the sample size requirements for PLS-SEM. The reason is that the algorithm does not compute all relationships in the structural model simultaneously. Instead, it uses Ordinary Least Squares regressions to estimate the model's partial regression relationships. Two early studies systematically evaluated the performance of Partial Least Square – Structural Equation Modeling (PLS-SEM) with small sample sizes and concluded it performed well. More recently, a simulation study by Reinartz et al. [44] indicated that PLS-SEM is a good choice when the sample size is small. Moreover, compared with its covariance-based counterpart, PLS-SEM has higher levels of statistical power in situations with complex model structures or smaller sample sizes [45]. Hence, a small sample size did not affect the validity and reliability of the study.

For this research, the data collected were analyzed using the SPSS 25 and SmartPLS 3 software. Through SPSS software, the data is analyzed by its percentage, mean, and standard deviation. Bivariate study is also conducted to find out the relationship between variables. By using SmartPLS 3 software, the path coefficient, bootstrapping, coefficient of determination (R-squared), effect size (F-squared), collinearity statistics (VIF), inner and outer VIF value, outer loading, and outer weights were analyzed. The hypothesis testing of the directional relationship of variables was conducted to test the null hypothesis of the variables. The results are discussed accordingly in the next section.

III. Results and Discussions

A total of 33 sets of questionnaires were distributed to the respondents. Out of the 33 sets of questionnaires, all of them were collected back. Therefore, this depicts 100% of response rate. Personal background of respondents are as follows:

TABLE II
BACKGROUND OF RESPONDENTS

Respondent ID	Gender	Age	Highest Level of Qualification	CGPA Last Semester
R1	Male	20	STPM	3.1 - 3.5
R2	Female	21	STPM	3.1 - 3.5
R3	Female	20	Matriculation	3.6 - 4.0
R4	Male	21	STPM	3.1 - 3.5
R5	Male	21	Diploma	3.1 - 3.5
R6	Female	20	STPM	3.1 - 3.5
R7	Female	20	Matriculation	3.1 - 3.5
R8	Female	21	Diploma	2.6 - 3.0
R9	Male	2[illegible]	Matriculation	3.1 - 3.5
R10	Female	21	STPM	3.1 - 3.5
R11	Male	21	Diploma	3.1 - 3.5
R12	Female	20	STPM	2.6 - 3.0
R13	Female	21	STPM	3.1 - 3.5
R14	Female	25	STPM	3.1 - 3.5
R15	Male	21	Matriculation	3.1 - 3.5
R16	Male	20	STPM	3.1 - 3.5
R17	Female	21	STPM	3.1 - 3.5
R18	Female	20	STPM	2.6 - 3.0
R19	Female	21	Matriculation	3.1 - 3.5
R20	Male	21	STPM	3.1 - 3.5
R21	Female	22	STPM	3.1 - 3.5
R22	Male	21	Matriculation	3.1 - 3.5
R23	Female	21	STPM	2.6 - 3.0
R24	Female	21	Diploma	3.1 - 3.5
R25	Female	21	STPM	3.1 - 3.5
R26	Female	20	Matriculation	2.6 - 3.0
R27	Male	21	STPM	3.1 - 3.5
R28	Female	21	STPM	3.1 - 3.5
R29	Male	21	STPM	3.1 - 3.5
R30	Male	23	Matriculation	2.6 - 3.0
R31	Female	21	STPM	3.1 - 3.5
R32	Female	25	STPM	3.1 - 3.5
R33	Female	21	STPM	3.1 - 3.5

There are 12 males (36.4%) and 21 females (63.6%) among the respondents. There are more females as compared to male respondents. Among the 33 respondents, there are 8 respondents (24.24%) who are 20 years old, 21 respondents (63.64%) who are 21 years old, 1 respondent each (3.03%) for 22 and 23 years old and 2 respondents (6.06%) who are 23 years old. The highest number of respondents are those who are 21 years old. Among the 33 respondents, only 1 respondent (3.0%) managed to obtain between 3.6 and 4.0 CGPA while 26 respondents (78.8%) obtained between 3.1 and 3.5 CGPA. A total of 6 respondents (18.2%) obtained between 2.6 and 3.0 CGPA, and no respondents obtained less than 2.5 CGPA.

TABLE III
CLASSIFICATION OF SURVEY RESPONDENTS

Classification	Responses	(%)
Gender rate		
Male	12	36.4
Female	21	63.6
Total	33	100.0
Age rate		
20	8	24.2
21	21	63.6
22	1	3.0
23	1	3.0
24	0	0
25	2	6.1
Total	33	100.0
CGPA last semester		
3.6 - 4.0	1	3.0
3.1 - 3.5	26	78.8
2.6 - 3.0	6	18.2
2.1 - 2.5	0	0.0
2.0 and below	0	0.0
Total	33	100.0

Table IV shows the percentage of understanding 2D interpretation, understanding 3D parametric modeling and the outcome of BIM learning in class by the respondents. These questions/items are measured using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Table IV shows the descriptive analysis of the questions, as well as the Mean and Standard Deviation (SD) of each question/item.

In this section, bivariate study is computed to study the relationship strength of each indicator in the variable. This is to show that these indicators have a mutual relationship or connection with the variable. Hence, it can prove that the indicators of the variable are indeed relevant and significant to the study. The bivariate study is computed in the SPSS 25. Since all the indicators and variables are ordinal, Spearman correlation is more suitable to be conducted to test the strength and direction.

Table V illustrates the bivariate study among the indicators in the variable. There are 20 indicators in this variable. The p-value of most of the indicators is significant towards one another ($p < 0.05$). As only a few indicators show low significant values, this does not interrupt the overall significance of the indicators in the study. This indicates that the indicators in the 2D digital interpretation variable are monotonic correlated and statistically significant to this study. All the indicators show a positive correlation and moderate linear relationship for the correlation coefficient.

Table VI illustrates the bivariate study among the indicators in the variable. There are six indicators in this variable. Most of the indicators show the p-value are significant to one another. This indicates that the indicators in the 3D Parametric Modeling variable are monotonic correlated and statistically significant to this study. For the correlation coefficient (r-value), all the indicators show a positive correlation and moderate linear relationship.

Table VII presents the bivariate study among the indicators in the variable. There are three indicators in this variable. Most of the indicators show the p-value is significant towards one another. This indicates that the Outcome from BIM Learning in Class variable indicators is monotonic correlated and statistically significant to this study. For the correlation coefficient (r-value), all the indicators show a moderate and positive linear correlation relationship.

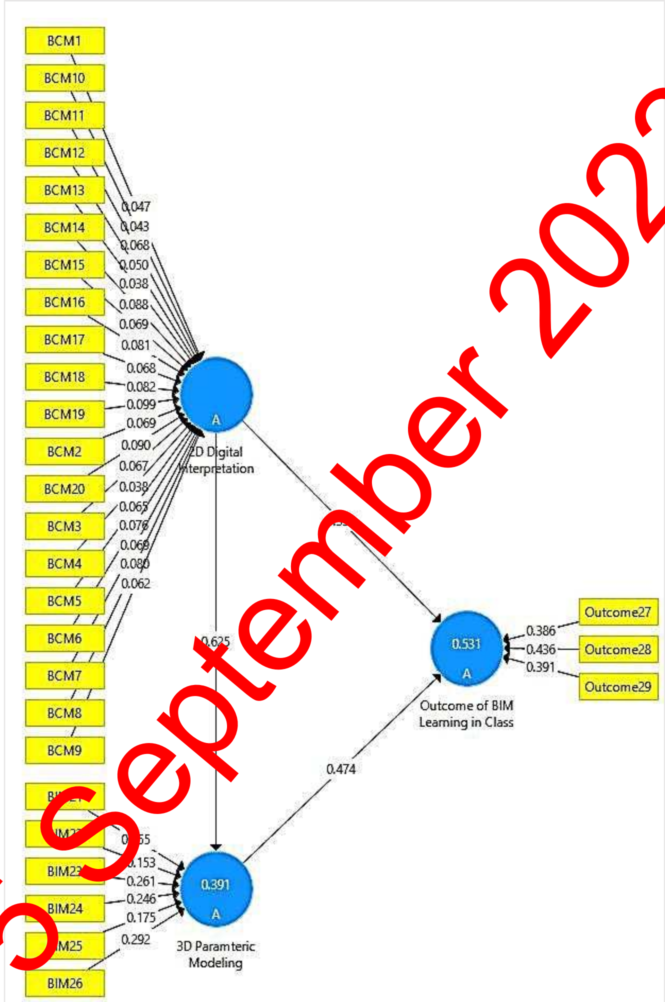

Fig. 1 PLS Algorithm Analysis Results Graph

Fig. 1 shows the results of PLS path algorithm of the three variables in the study: 1) 2D digital interpretation, 2) 3D parametric modeling, and 3) Outcome from BIM learning in class. The model above is drawn in a way to show that these three variables are inter-related with each other to fulfill the objectives of the study, which are:

- To explore the key elements of BIM learning in undergraduate construction management.
- To evaluate the understanding and interpretation of 2D digital drawings and its correlation to learning 3D parametric modelling.
- To examine the relationship of understanding and Interpretation of 2D digital drawings and 3D parametric modelling learning components towards the outcome of BIM learning progress.

TABLE IV
PERCENTAGE, MEAN & STANDARD DEVIATION OF UNDERSTANDING 2D DIGITAL INTERPRETATION, 3D PARAMETRIC MODELLING AND OUTCOME FROM BIM LEARNING

			Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
1.	BCM1	I can recognize commonly used graphical symbols and representation in building, mechanical and electrical drawings etc..			57.6%	30.3%	12.1%	3.545	0.711
2.	BCM2	I understand the types and purposes of different drawings and plans.			33.3%	51.5%	15.2%	3.818	0.6825
3.	BCM3	I know drawing and plans that are required for construction, and the relevant authority.		3.0%	30.3%	42.4%	24.2%	3.878	0.8199
4.	BCM4	I know the users of each type of drawing.		9.1%	39.4%	36.4%	15.1%	3.531	0.8418
5.	BCM5	I can state a range of standard scales for the site plans, floor plans and elevations.		12.1%	36.4%	39.4%	12.1%	3.515	0.8703
6.	BCM6	I can identify various drafting tools, materials and equipment.		9.1%	45.5%	33.3%	12.1%	3.484	0.8337
7.	BCM7	I understand the application of 2D modelling.	3.0%	9.1%	36.4%	42.4%	9.1%	3.454	0.9045
8.	BCM8	In 2D software, I can use some commands and user interface elements including file navigation, the ribbon, viewports, units display, scale etc.		12.1%	51.5%	27.3%	9.1%	3.333	0.8165
9.	BCM9	I can explain the working principles of printing machine or device.		6.1%	45.5%	39.4%	9.1%	3.515	0.7550
10.	BCM10	I know the basic principles of design.		3.0%	45.5%	42.4%	9.1%	3.575	0.7084
11.	BCM11	I can identify the part of a typical residential bungalow living room, kitchen, rooms, porch etc.			24.2%	45.5%	30.3%	4.060	0.7474
12.	BCM12	I can identify electrical, sanitary and water services,soak away etc.			36.4%	48.5%	15.2%	3.787	0.6963
13.	BCM13	I know the purpose of town planning authority regulations.			57.6%	33.3%	9.1%	3.515	0.6671
14.	BCM14	I know features that may influence the design of a residential building.			51.5%	36.4%	12.1%	3.606	0.7044
15.	BCM15	I know the purpose of preliminary sketch design.		9.1%	27.3%	48.5%	15.2%	3.697	0.8472
16.	BCM16	I can determine the feature/characteristics of a given surveyor's plan e.g. solar orientation, plot size etc.		15.2%	45.5%	30.3%	9.1%	3.333	0.8539
17.	BCM17	I can describe the title block, legend properties, and notes.		9.1%	48.5%	27.3%	15.2%	3.484	0.8703
18.	BCM18	I can distinguish the line weight and the elements/materials being represented.		15.2%	45.5%	30.3%	9.1%	3.393	0.9333
19.	BCM19	I can distinguish dimension line, extension line and the rules of application.	3.0%	18.2%	36.4%	30.3%	12.1%	3.30	1.0150
20.	BCM20	I can state the main purpose of sectioning / section drawings.		12.1%	39.4%	30.3%	18.2%	3.545	0.9384
21.	BIM21	I can plan, create and maintain a BIM model.	3.0%	12.1%	63.6%	15.2%	6.1%	3.091	0.8048
22.	BIM22	I can communicate effectively with other students in BIM learning.	3.0%	12.1%	30.3%	45.5%	9.1%	3.455	0.9385
23.	BIM23	I can navigate the BIM software easily to view the model.		15.2%	54.5%	30.3%		3.152	0.6671
24.	BIM24	I can find the information and definitions embedded in the model elements easily.		15.2%	54.5%	27.3%	3.0%	3.364	0.7269
25.	BIM25	I can identify better the individual elements of a model easier on BIM compared to 2D software.		15.2%	48.5%	21.2%	15.2%	3.364	0.9293
26.	BIM26	I can understand how to function BIM software (E.g. Glodon Cubicost, Autodesk Revit) now.	3.0%	30.3%	39.4%	21.2%	6.1%	2.970	0.9515
27.	OUTCOME27	I can overcome learning difficulties through BIM courses.	3.0%	9.1%	39.4%	33.3%	15.2%	3.485	0.9722
28.	OUTCOME28	I have improved my CGPA through BIM courses.	3.0%	12.1%	39.4%	27.3%	18.2%	3.455	3.6667
29.	OUTCOME29	I see myself as prepared to work in the industry as a result of my course experience.		6.1%	39.4%	36.4%	18.2%	3.667	0.8539

TABLE V
CORRELATION BETWEEN ITEMS IN 2D DIGITAL INTERPRETATION

		BC M1	BC M2	BC M3	BC M4	BC M5	BC M6	BC M7	BC M8	BC M9	BC M10	BC M11	BC M12	BC M13	BC M14	BC M15	BC M16	BC M17	BC M18	BC M19	BC M20
BC M1	Correlation Coefficient (r)		0.516	0.447	0.414	0.293	0.238	0.306	0.224	0.263	0.300	0.393	0.573	0.27[illegible]	0.208	0.209	0.095	0.349	0.209	0.151	0.189
	Sig. (p)		0.002	0.009	0.017	0.097	0.181	0.083	0.209	0.140	0.090	0.024	0.00[illegible]	0.120	0.244	0.243	0.600	0.046	0.243	0.402	0.292
BC M2	Correlation Coefficient (r)	0.510		0.349	0.401	0.422	0.660	0.476	0.414	0.333	0.573	[illegible]	0.599	0.247	0.508	0.380	0.471	0.440	0.475	0.424	0.542
	Sig. (p)	0.002		0.047	0.021	0.014	0.000	0.005	0.017	0.058	0.000	0.000	0.000	0.165	0.003	0.029	0.006	0.010	0.005	0.014	0.001
BC M3	Correlation Coefficient (r)	0.447	0.349		0.471	0.300	0.360	0.356	0.546	0.402	0.363	0.414	0.350	0.560	0.529	0.439	0.311	0.447	0.381	0.447	0.431
	Sig. (p)	0.009	0.047		0.006	0.090	0.039	0.042	0.001	0.02[illegible]	0.038	0.017	0.046	0.001	0.002	0.010	0.078	0.009	0.029	0.009	0.012
BC M4	Correlation Coefficient (r)	0.414	0.401	0.471		0.322	0.432	0.491	[illegible]	0.335	0.413	0.393	0.508	0.319	0.483	0.350	0.440	0.554	0.481	0.464	0.433
	Sig. (p)	0.017	0.021	0.006		0.068	0.012	0.004	0.021	0.057	0.017	0.024	0.003	0.070	0.004	0.046	0.010	0.001	0.005	0.006	0.012
BC M5	Correlation Coefficient (r)	0.293	0.422	0.300	0.322		0.591	0.558	0.659	0.479	0.438	0.553	0.509	0.335	0.420	0.543	0.665	0.545	0.533	0.571	0.727
	Sig. (p)	0.097	0.014	0.090	0.068		0.000	0.001	0.000	0.005	0.011	0.001	0.003	0.056	0.015	0.001	0.000	0.001	0.001	0.001	0.000
BCM6	Correlation Coefficient (r)	0.238	0.660	0.360	[illegible]	0.591		0.522	0.585	0.521	0.605	0.591	0.467	0.501	0.628	0.698	0.748	0.636	0.597	0.659	0.720
	Sig. (p)	0.181	0.000	0.039	0.012	0.000		0.002	0.000	0.002	0.000	0.000	0.006	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BC M7	Correlation Coefficient (r)	0.306	0.476	0.356	0.491	0.558	0.522		0.669	0.562	0.375	0.445	0.392	0.232	0.507	0.445	0.493	0.514	0.563	0.671	0.560
	Sig. (p)	0.083	0.005	0.042	0.004	0.001	0.002		0.000	0.001	0.031	0.009	0.024	0.194	0.003	0.010	0.004	0.002	0.001	0.000	0.001
BC M8	Correlation Coefficient (r)	[illegible]	0.414	0.546	0.401	0.659	0.585	0.660		0.522	0.337	0.467	0.318	0.360	0.723	0.639	0.519	0.429	0.505	0.611	0.711

	Sig. (p)	0.209	0.017	0.001	0.021	0.000	0.000	0.000		0.002	0.055	0.006	0.071	0.039	[illegible]	[illegible]	0.002	0.013	0.003	0.000	0.000
	Correlation Coefficient (r)	0.263	0.333	0.402	0.335	0.479	0.521	0.562	0.522		0.625	0.525	0.216	0.343	0.314	0.299	0.544	0.710	0.641	0.737	0.544
BC M9	Sig. (p)	0.140	0.058	0.020	0.057	0.005	0.002	0.001	0.002		0.000	0.002	0.228	[illegible]	0.075	0.091	0.001	0.000	0.000	0.000	0.001
	Correlation Coefficient (r)	0.300	0.573	0.363	0.413	0.438	0.605	0.375	0.337	0.625		0.702	[illegible]	0.514	0.343	0.249	0.381	0.635	0.519	0.508	0.460
BC M10	Sig. (p)	0.090	0.000	0.038	0.017	0.011	0.000	0.031	0.055	0.000		[illegible]	[illegible]	0.002	0.050	0.162	0.029	0.000	0.002	0.003	0.006
	Correlation Coefficient (r)	0.393	0.634	0.414	0.393	0.553	0.591	0.445	0.467	0.525	[illegible]		0.350	0.556	0.427	0.369	0.488	0.579	0.424	0.460	0.624
BC M11	Sig. (p)	0.024	0.000	0.017	0.024	0.001	0.000	0.009	0.006	0.002	[illegible]		0.046	0.001	0.013	0.035	0.004	0.000	0.014	0.007	0.000
	Correlation Coefficient (r)	0.573	0.599	0.350	0.508	0.509	0.467	0.392	0.318	[illegible]	0.377	0.350		0.217	0.349	0.479	0.363	0.431	0.289	0.308	0.383
BC M12	Sig. (p)	0.000	0.000	0.046	0.003	0.003	0.006	0.024	[illegible]	0.228	0.031	0.046		0.225	0.047	0.005	0.038	0.012	0.103	0.081	0.028
	Correlation Coefficient (r)	0.276	0.247	0.562	0.319	0.335	0.501	[illegible]	0.360	0.343	0.514	0.556	0.217		0.424	0.419	0.382	0.610	0.404	0.389	0.448
BC M13	Sig. (p)	0.120	0.165	0.001	0.070	0.056	[illegible]	0.194	0.039	0.051	0.002	0.001	0.225		0.014	0.015	0.028	0.000	0.020	0.025	0.009
	Correlation Coefficient (r)	0.208	0.508	0.529	0.483	[illegible]	0.628	0.507	0.723	0.314	0.343	0.427	0.349	0.424		0.662	0.517	0.372	0.481	0.518	0.623
BC M14	Sig. (p)	0.244	0.003	0.002	[illegible]	[illegible]	0.000	0.003	0.000	0.075	0.050	0.013	0.047	0.014		0.000	0.002	0.033	0.005	0.002	0.000
	Correlation Coefficient (r)	0.209	0.380	[illegible]	[illegible]	0.543	0.698	0.445	0.639	0.299	0.249	0.369	0.479	0.419	0.662		0.579	0.409	0.274	0.364	0.436
BC M15	Sig. (p)	0.243	[illegible]	[illegible]	0.046	0.001	0.000	0.010	0.000	0.091	0.162	0.035	0.005	0.015	0.000		0.000	0.018	0.122	0.037	0.011
	Correlation Coefficient (r)	0.095	[illegible]	0.311	0.440	0.665	0.748	0.493	0.519	0.544	0.381	0.488	0.363	0.382	0.517	0.579		0.604	0.668	0.700	0.758
BC M16	Sig. (p)	[illegible]	0.006	0.078	0.010	0.000	0.000	0.004	0.002	0.001	0.029	0.004	0.038	0.028	0.002	0.000		0.000	0.000	0.000	0.000

BC M17	Correlation Coefficient (r)	0.349	0.440	0.447	0.554	0.545	0.636	0.514	0.429	0.710	0.635	0.579	0.431	0.610	[illegible]	[illegible]	0.604		0.760	0.686	0.604
	Sig. (p)	0.046	0.010	0.009	0.001	0.001	0.000	0.002	0.013	0.000	0.000	0.000	0.012	0.000	0.033	0.018	0.000		0.000	0.000	0.000
BC M18	Correlation Coefficient (r)	0.209	0.475	0.381	0.481	0.533	0.597	0.563	0.505	0.641	0.519	0.424	0.289	[illegible]	0.481	0.274	0.668	0.760		0.858	0.708
	Sig. (p)	0.243	0.005	0.029	0.005	0.001	0.000	0.001	0.003	0.000	0.002	0.014	[illegible]	0.020	0.005	0.122	0.000	0.000		0.000	0.000
BC M19	Correlation Coefficient (r)	0.151	0.424	0.447	0.464	0.571	0.659	0.671	0.611	0.737	0.508	0.460	[illegible]	0.389	0.518	0.364	0.700	0.686	0.858		0.767
	Sig. (p)	0.402	0.014	0.009	0.006	0.001	0.000	0.000	0.000	0.000	0.003	0.007	0.081	0.025	0.002	0.037	0.000	0.000	0.000		0.000
BC M20	Correlation Coefficient (r)	0.189	0.542	0.431	0.433	0.727	0.720	0.560	0.711	0.544	[illegible]	0.624	0.383	0.448	0.623	0.436	0.758	0.604	0.708	0.767	
	Sig. (p)	0.292	0.001	0.012	0.012	0.000	0.000	0.001	0.000	0.001	0.006	0.000	0.028	0.009	0.000	0.011	0.000	0.000	0.000	0.000	
	N	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	33.000	

Note:

BCM1 - I can recognise commonly used graphical symbols and representation in building, mechanical and electrical drawings etc.
BCM2 - I understand the types and purposes of different drawings and plans.
BCM3 - I know drawing and plans that are required for construction, and the relevant authority.
BCM4 - I know the users of each type of drawing.
BCM5 - I can state a range of standard scales for the site plans, floor plans and elevations.
BCM6 - I can identify various drafting tools, materials and equipment.
BCM7 - I understand the application of 2D modelling.
BCM8 - In 2D software, I can use some commands and user interface elements including file navigation, the ribbon, viewports, units display, scale etc.
BCM9 - I can explain the working principles of printing machine or device.
BCM10 - I know the basic principles of design.
BCM11 - I can identify the part of a typical residential bungalow living room, kitchen, rooms, porch etc.
BCM12 - I can identify electrical, sanitary and water services, soakaway etc.
BCM13 - I know the purpose of town planning authority regulations.
BCM14 - I know features that may influence the design of a residential building.
BCM15 - I know the purpose of preliminary sketch design.
BCM16 - I can determine the feature/characteristics of a given surveyor’s plan e.g., solar orientation, plot size etc.
BCM17 - I can describe the title block, legend properties, and notes.
BCM18 - I can distinguish the line weight and the elements/materials being represented.
BCM19 - I can distinguish dimension line, extension line and the rules of application.
BCM20 - I can state the main purpose of sectioning / section drawings.

TABLE VI

CORRELATION BETWEEN INDICATORS IN 3D PARAMETRIC MODELLING

		BIM21	BIM22	BIM23	BIM24	BIM25	BIM26
BIM21	Correlation Coefficient (r)		0.536	0.425	0.487	0.170	0.546
	Sig. (p)		0.001	0.014	0.004	0.345	0.001
BIM22	Correlation Coefficient (r)	0.536		0.379	0.617	0.264	0.400
	Sig. (p)	0.001		0.029	0.000	0.138	0.021
BIM23	Correlation Coefficient (r)	0.425	0.379		0.785	0.514	0.514
	Sig. (p)	0.014	0.029		0.000	0.002	0.002
BIM24	Correlation Coefficient (r)	0.487	0.617	0.785		0.575	0.316
	Sig. (p)	0.004	0.000	0.000		0.000	0.073
BIM25	Correlation Coefficient (r)	0.170	0.264	0.514	0.575		0.266
	Sig. (p)	0.345	0.138	0.002	0.000		0.135
BIM26	Correlation Coefficient (r)	0.546	0.400	0.514	0.316	0.266	
	Sig. (p)	0.001	0.021	0.002	0.073	0.135	

Note:
BIM21 - I can plan, create and maintain a BIM model.
BIM22 - I can communicate effectively with other students in BIM learning.
BIM23 - I can navigate the BIM software easily to view the model.
BIM24 - I can find the information and definitions embedded in the model elements easily.
BIM25 - I can identify better the individual elements of a model easier on BIM compared to 2D software.
BIM26 - I can understand how to function BIM software (e.g., Glodon Cubicost, Autodesk Revit) now.

TABLE VII

CORRELATION BETWEEN ITEMS IN OUTCOME FROM BIM LEARNING IN CLASS

		Outcome27	Outcome28	Outcome29
Outcome27	Correlation Coefficient(r)		0.540	0.499
	Sig. (p)		0.001	0.003
Outcome28	Correlation Coefficient (r)	0.540		0.592
	Sig. (p)	0.001		0.000
Outcome29	Correlation Coefficient (r)	0.499	0.592	
	Sig. (p)	0.003	0.000	

Note:
Outcome27 - I can overcome learning difficulties through BIM courses.
Outcome28 - I have improved my CGPA through BIM courses.
Outcome29 - I see myself as prepared to work in the industry as a result of my course experience.

The path coefficient from 2D digital Interpretation to 3D parametric modeling has a coefficient value of 0.625. The path weight of 0.625 shows that 2D digital Interpretation has a medium positive effect on 3D parametric modeling. Next, in the path from 2D digital to outcome from BIM learning in class has a coefficient value of 0.332. The path weight of 0.332 shows that 2D digital Interpretation has a slightly weak positive effect on the outcome of BIM learning in the class. The path coefficient from 3D parametric modelling to outcome from BIM learning also has a coefficient value of 0.474. The path weight of 0.474 shows that 3D parametric modeling has a medium positive on the outcome of BIM learning in class.

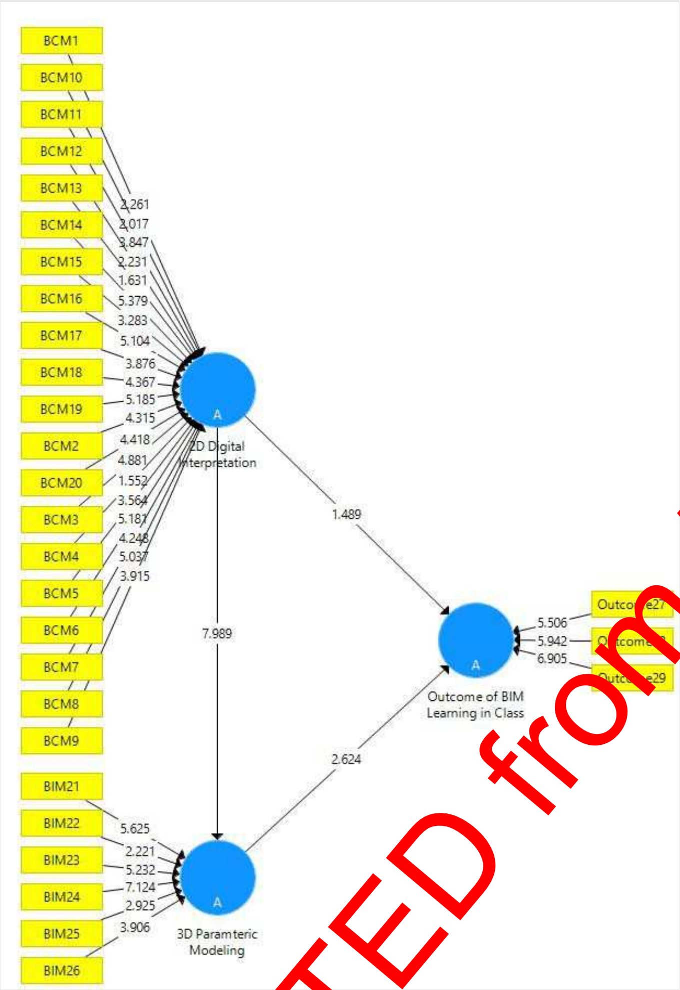

Fig. 2 Bootstrapping Results Graph

Table VIII shows the T-values and P-values in this study. The relationship between 2D digital Interpretation and 3D parametric modeling is significant ($p < 0.05$, $t > 1.96$). The relationship between 3D parametric modeling and outcome from BIM learning in class shows a significant correlation ($p < 0.05$, $t > 1.96$). However, the relationship between 2D parametric modeling and outcome from BIM learning in class show a non-significant correlation ($p > 0.05$, $t < 1.96$).

As seen in the PLS Algorithm model above, the results of the R-squared is summarized in Table IX. It is better to look at the adjusted R-squared value rather than the R-squared value because adjusted R-squared values are calculated based on those significant variables in the model where it increased irrespective of the variable significance.

TABLE VIII
SUMMARY OF BOOTSTRAPPING RESULTS

Predecessor	Successor	T-value	P-value
2D Digital Interpretation	3D Parametric Modeling	7.952	0.000
2D Digital Interpretation	Outcome from BIM Learning in Class	1.501	0.13[illegible]
3D Parametric Modeling	Outcome from BIM Learning in Class	2.498	0.01[illegible]

TABLE IX
SUMMARY OF R-SQUARED RESULTS

Predecessor	Successor	R Square	R Square Adjusted	Result
2D Digital Interpretation	3D Parametric Modeling	0.391	0.372	Slightly Weak
2D Digital Interpretation & 3D Parametric Modeling	Outcome from BIM Learning in Class	0.5[illegible]1	0.500	Moderate

Furthermore, R-squared values are used to explain the degree of which input variables explain the most variation of the output variable. In this study, 3D parametric modeling successor has R-squared result of 0.372, which means 37.2% of the variation in the 3D parametric modeling can be explained by the 2D digital Interpretation. Besides that, 2D digital Interpretation and 3D parametric modeling have the R-squared value of 0.500.

TABLE X
SUMMARY OF F-SQUARED RESULTS

	2D Digital Interpretation	3D Parametric Modeling	Outcome from BIM Learning in Class
2D Digital Interpretation		0.624 (high)	0.143 (medium)
3D Parametric Modeling			0.292 (medium)
Outcome from BIM Learning in Class			

Table X shows that 2D digital Interpretation has a high effect on 3D parametric modelling (0.624). 2D digital Interpretation and 3D parametric modelling both have a medium effect on the outcome from BIM learning in class (0.143 and 0.292, respectively).

Table XI and Table XII show this study's inner and outer VIF values. For the outer VIF value, all the values are situated below 10. The VIFs are all less than 10, indicating that multicollinearity is not a serious concern [46], [47], [48]. Therefore, it shows that the threshold values are acceptable. The hypotheses of this study are analyzed, and the results are shown in Table XIII.

TABLE XI
SUMMARY OF INNER VIF VALUE RESULTS

	2D Digital Interpretation	3D Parametric Modeling	Outcome from BIM Learning in Class
2D Digital Interpretation		1.000	1.642
3D Parametric Modeling			1.642
Outcome from BIM Learning in Class			

TABLE XII
SUMMARY OF OUTER VIF VALUE RESULTS

Items	Details	VIF Value
2D Digital Interpretation		
BCM1	I can recognize commonly used graphical symbols and representation in building, mechanical and electrical drawings etc..	2.711
BCM2	I understand the types and purposes of different drawings and plans.	6.370
BCM3	I know drawing and plans that are required for construction, and the relevant authority.	2.928
BCM4	I know the users of each type of drawing.	2.828
BCM5	I can state a range of standard scales for the site plans, floor plans and elevations.	5.524
BCM6	I can identify various drafting tools, materials and equipment.	8.774
BCM7	I understand the application of 2D modelling.	3.985
BCM8	In 2D software, I can use some commands and user interface elements including file navigation, the ribbon, viewports, units display, scale etc.	6.782
BCM9	I can explain the working principles of printing machine or device.	5.332
BCM10	I know the basic principles of design.	5.207
BCM11	I can identify the part of a typical residential bungalow living room, kitchen, rooms, porch etc.	4.060
BCM12	I can identify electrical, sanitary and water services, soak away etc.	4.500
BCM13	I know the purpose of town planning authority regulations.	4.110
BCM14	I know features that may influence the design of a residential building.	3.965
BCM15	I know the purpose of preliminary sketch design.	6.26[illegible]
BCM16	I can determine the feature/characteristics of a given surveyor's plan e.g., solar orientation, plot size etc.	5.474
BCM17	I can describe the title block, legend properties and notes.	7.190
BCM18	I can distinguish the line weight and the elements/materials being represented.	7.872
BCM19	I can distinguish dimension line, extension line and the rules of application.	8.432
BCM20	I can state the main purpose of sectioning/section drawings.	7.107
3D Parametric Modeling		
BIM21	I can plan, create and maintain a BIM model.	1.624
BIM22	I can communicate effectively with other students in BIM learning.	1.903
BIM23	I can navigate the BIM software easily to view the model.	3.406
BIM24	I can find the information and definitions embedded in the model elements easily.	4.215
BIM25	I can identify better the individual elements of a model easier on BIM compared to 2D software.	1.543
BIM26	I can understand how to function BIM software (e.g., Glodon Cubicost, Autodesk Revit) now.	1.711
Outcome from BIM Learning in Class		
OUTCOME27	I can overcome learning difficulties through BIM courses.	1.519
OUTCOME28	I have improved my CGPA through BIM courses.	1.583
OUTCOME29	I see myself as prepared to work in the industry as a result of my course experience.	1.543

TABLE XIII
SUMMARY OF HYPOTHESIS TESTING RESULTS

Hyp.	Relationship	Sample Mean	Std. Deviation	T-value	P-value	Decision
H1	2D digital Interpretation -> 3D parametric modeling	0.657	0.078	7.952	0.000*	Supported
H2	2D digital Interpretation -> Outcome of BIM learning in Class	0.326	0.22[illegible]	1.501	0.134*	Rejected
H3	3D parametric modeling -> Outcome of BIM learning in Class	0.[illegible]91	0.193	2.498	0.013*	Supported
H4	2D digital interpretation & 3D parametric modeling -> Outcome of BIM learning in Class	Not supported. Since H2 is rejected while H3 is supported.				

*Significance at $p < 0.05$
Note:
H1: 2D digital Interpretation does significantly contribute to 3D parametric modeling.
H2: 2D digital Interpretation does significantly contribute to the outcome of BIM learning in class.
H3: 3D parametric modeling does significantly contribute to the outcome of BIM learning in class.
H4: Both 2D digital Interpretation and 3D parametric modeling do contribute to the outcome of BIM learning.

Based on the data in Table XIII, the results show that H1 is significant at p = 0.000 and positively related to 3D parametric modeling. However, H2 is not significant as p > 0.050, which shows that 2D digital Interpretation is not related to the outcome of BIM learning in class. Furthermore, H3 is significant at p = 0.013, and this shows that it is positively related to the outcome of BIM learning in class. Lastly, H4 is not supported because 2D digital Interpretation does not have a relationship with the outcome of BIM learning in class. Hence, this hypothesis is rejected even though 3D parametric modeling relates to the outcome of BIM learning in class.

Furthermore, according to Caroline Clevenger [20]'s research in 'Integrating BIM into Construction Management Education' stated "*As all VIF values are below the threshold of 5, we can conclude that collinearity is not a critical issue... We also find that the model explains 56.2% of CUSL's variance (i.e., R2 = 0.562), which is relatively high considering that the model only considers the effects of customer satisfaction and the rather abstract concept of corporate reputation as predictors of customer loyalty.*" Since the majority of the indicators have had a value lesser than 5, the VIFs have no issues. In addition, high T-values indicate statistically significant relationships between variables. Based on Hair et al. [49] description, all T-values above 1.96 are significant when P-value is less than 0.05, which is the case for all T-values in our research model. When a P-value is 0.000, it is more significant than the 0.001 probability level. When the T-value is greater than 1.96 and the P-value is smaller than 0.05, the hypotheses are supported or otherwise.

However, the most important test is bootstrapping test, which shows the significance of the variables to the study. According to Caroline Clevenger [20]'s research in 'Integrating BIM into Construction Management Education' which also stated "We assess whether critical levels of collinearity substantially affect *the formative indicator weight estimates. We find that the highest VIF value is clearly below the threshold value of 5, suggesting that collinearity is not at a critical level. Testing the indicator weights' significance draws on the bootstrapping procedure…we retain the nonsignificant, but relevant, indicators in the formative measurement models.*" The bootstrapping results show that the hypothesis, H2: 2D digital interpretation, significantly contribute to the outcome of BIM learning in class. However, the 2D digital Interpretation is not significant as p-value = 0.134. This shows that it is not related to the outcome of BIM learning in class. While for hypothesis H3: 3D parametric modeling does significantly contribute to the outcome of BIM learning in class, the 3D parametric modeling is significant at p = 0.013. This shows that it is positively related to the outcome of BIM learning in class. Although 2D digital Interpretation does not significantly contribute to the outcome of BIM learning in class 3D parametric modeling, on the other hand, contribute to the outcome of BIM learning.

The SPSS results show that, in the first variable of 2D digital Interpretation, the mean score for this section averages between 3.30 and 4.06, where the former (BCM19: I can distinguish dimension line, extension line and the rules of application.) is the lowest and the latter (BCM11: I can identify the part of a typical residential bungalow living room, kitchen, rooms, porch etc.) is the highest. The highest mean score (4.06) falls under the question "I can identify the part of a typical residential bungalow living room, kitchen, rooms, porch etc". This shows that most students understand how to identify different parts of a residential building. The lowest mean score (3.30) falls under the question "I can distinguish dimension line, extension line, and the rules of application". The low mean score shows that the students could not differentiate between dimension lines, extension lines, and other types of line applications in 2D drawings. This shows that the information that carries by BIM software is abundant, where students need more time to digest the implementation of BIM software in their undergraduate but not when they join the industry later [8], [12], [42]. In the second variable of 3D parametric modeling, the mean score for this section averages between 2.97 and 3.455, where the former (BIM26: I can understand how to function BIM software (e.g., Glodon Cubicost, Autodesk Revit) now.) is the lowest, and the latter (OUTCOME28: I have improved my CGPA through BIM courses.) is the highest. The mean scores can be interpreted as the respondents feeling neutral about these items under the understanding 3D parametric modeling section. The highest mean score (3.455) falls under the question of "I can communicate effectively with other students in BIM learning". This shows that the students can work together and communicate effectively with other students during BIM learning in class. The lowest mean score (2.97) falls under the question "I can understand how to function BIM software (e.g., Glodon Cubicost, Autodesk Revit) now". This shows that the respondents still have less knowledge of how to use BIM software, even though they had a few previous BIM lessons.

The results show that the incorporation of BIM software in the curricular of undergraduate has helped to improve the students' competency where they have fundamental knowledge on the operation of BIM software when they join the industry after graduation [3], [11]. In the third variable of outcome of BIM learning in class, the mean score for this section averages between 3.455 and 3.667, where the former (OUTCOME28: I have improved my CGPA through BIM courses.) is the lowest, and the latter (OUTCOME29: I see myself as prepared to work in the industry as a result of my course experience.) is the highest. The mean scores can be interpreted as the respondents feeling neutral as well for these items under the outcome of BIM learning in class. The highest mean score (3.667) falls under the question "I see myself as prepared to work in the industry as a result of my course experience". This shows that the respondents are unsure whether they feel prepared in working in the industry. The lowest Mean score (3.455) falls under the question "I have improved my CGPA through BIM courses". This shows that the respondents felt neutral towards improving CGPA through BIM courses. Students' confidence level improved significantly after the incorporation of BIM software in the curricular and their competency increased drastically which would help students in pursuing better job opportunity [12].

Next, the bivariate studies for the items in the three variables: 2D digital Interpretation, 3D parametric modeling, and the outcome of BIM learning in class show that almost all items are significant towards one another since most of the p-values are less than 0.05. This indicates that the items in the 2D digital Interpretation, 3D parametric modeling and the outcome of BIM learning in class variables are monotonic correlated and are statistically significant to this study. For the correlation coefficient, all items show a positive correlation. Most of the items show a moderate linear relationship, even though some items show weak and strong linear relationships. Effect size or F-squared measures the sizes of difference and one variable's effect size. Results show that 2D digital Interpretation has a high effect on 3D parametric modeling (0.624). 2D digital Interpretation and 3D parametric modeling both have a medium effect on the outcome from BIM learning in class (0.143 and 0.292, respectively). Therefore, tertiary learning institutions should ensure all students have basic 2D knowledge through the learning from the CAD software before they can fully understand and utilize the adoption of BIM software in the curricular [8]. Based on the results obtained from SmartPLS 3, the path coefficient from 2D digital Interpretation to 3D parametric modeling has a coefficient of positive 0.625. The path weight of 0.625 shows that 2D digital Interpretation has a medium positive effect on 3D parametric modeling.

Next, the path from 2D digital to outcome from BIM learning in class has a path weight of 0.332, which shows that 2D digital Interpretation has a slightly weak positive effect on outcomes of BIM learning in class. The path coefficient from 3D parametric modeling to outcome from BIM learning also has a coefficient of positive 0.474, which is medium positive on the outcome of BIM learning in class. For the R-squared value, 50% of the variation in the outcome from BIM learning in class can be explained by 2D digital Interpretation and 3D parametric modeling. For the F-squared value, 2D digital Interpretation and 3D parametric modeling both have a medium effect on the outcome from BIM learning in class, respectively. Therefore, the university must enhance the syllabus to ensure both 2D and 3D relevant subjects can help students get used to BIM environment [11].

IV. Conclusion

This research has successfully explored the key elements of BIM learning among undergraduate construction management students. The literature review determines the BIM elements from 2D digital Interpretation, 3D parametric modeling and the outcomes of BIM learning in class. From the findings, the importance of each BIM elements is inter-related for BIM learning to be efficient. Bivariate study has also been conducted in the SPSS software to show the overall significance of the items to study. Even though there were some items that were not significant, it does not affect the overall significance of all items in this study. Overall, the study discovered that the students are average in their literacy level of using digital and BIM technology. It means that the students need more BIM lessons to improve their digital and BIM knowledge [3], [12]. Even though the bootstrapping results of SPSS software prove that 2D digital Interpretation does not have a relationship with the outcome of BIM learning in class, it is still vital for students to gain digital knowledge so that they are well prepared to enter the working industry. Since 3D parametric modeling has a significant relationship with the outcome of BIM learning in class, BIM education is necessary for the development of the students.

Therefore, as researched by Ferrer-Estévez and Chalmeta [7], it is important to teach BIM education to university students. This is in line with Ferrer-Estévez and Chalmeta [7]'s perspective, who mentioned that BIM education equals necessary knowledge and BIM skills acquisition to produce students with BIM competencies. This is supported by other researchers such as Wang and Liu [8] and Zamora-Polo, et al. [11], who mentioned formal education, in-house training, and professional development as the ways to improve BIM competencies [7]. Hence, BIM education is necessary to be incorporated into the university syllabus to develop the students further and prepare them before working.

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