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COMPREHENSIVE ANALYSIS ON BIM LEARNING IN ARCHITECTURE UNDERGRADUATE STUDENTS IN INDONESIA

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Abstract

The use of software in architecture has become a necessary skill to effectively communicate designs and coordinate with stakeholders involved in the studio process. Building Information Modelling (BIM) has been integrated into the architectural education curriculum. Designing with BIM can shorten project timelines, thereby maximizing design exploration. This research aims to provide an overview of the BIM learning process in architectural studios. Data was collected through questionnaires distributed to respondents, focusing on architecture students across Indonesia. Additionally, the BIM learning process will be compared with pre-BIM software: the constraints and their influence on student design development are also key focuses of this research, captured through three stages of questionnaires: at the beginning of the semester, mid-semester, and end of the semester. The findings suggest that learning BIM in architectural studios requires adaptation, but is viewed as an important skill for career survival from the students' perspective, thus motivating their learning process.

***Keywords**: Architecture; Learning; Studio, Building Information Modelling*

INTRODUCTION

Building Information Modeling (BIM) in architectural education has become one of the most important innovations in the construction industry during this digital era. In Indonesia, the adoption of BIM in architecture higher education curriculum is starting to grow along with the increasing need for a skilled and adaptive workforce towards advanced technology. BIM is a technology that enables the creation and management of digital models of a building, covering various aspects from design, construction, to operation. BIM can also be used in other aspects of architecture besides design, such as heritage preservation (Alya et al., 2023) and redrawing vernacular buildings (Savaşkan & Özener, 2022). In the educational context, BIM therefore provides an opportunity for students to understand architectural projects holistically through realistic and integrated simulations.

BIM was first introduced around 1970 (Ingram, 2020), and continues to grow to this day. BIM usage in the architectural professional field is supported by government policies. The Indonesian Ministry of Public Works and Housing issued Ministerial Regulation Number 22/PRT/M/2018 (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2018) that mandates the imperative use of BIM for the construction of state buildings. This regulation indirectly encourages architectural education institutions to integrate BIM in their curricula. Besides, the presence of Government Regulation Number 16/2021, regarding the implementation of Law 28/2002 (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2021) also emphasizes the importance of using modern technology in planning and construction, including BIM. These two regulations emphasize the importance of BIM as an industry standard, which ultimately affects the architectural education system to prepare graduates who are competent in the technology.

LITERATURE STUDY

Research on BIM implementation from a pedagogical university perspective has been conducted several times before, with the results of several crucial aspects in its success, such as vision and priorities, infrastructure, curriculum, human resource conditions, university organization, and management (Maharika et al., 2020). In another study, barriers to the use of BIM in the context of architectural education in Nigeria have also been found, namely computer specifications, the need for intensive training, the presence of stable electricity, and sufficient time for sufficient mastery (Maina, 2018). Another study in Australia found 4 barriers to BIM learning, namely updates in management due to the use of BIM as software, curriculum integration, teaching personnel constraints, and misalignment with architectural work practices (Casasayas et al., 2021). Research in Malaysia states that the use of BIM in architecture studios in public and private universities is still limited to BIM phase 1, namely 3D modeling and 2D drafting using BIM (Tanko & Mbugua, 2022).

Previous research has also found that mastery of BIM is closely related to an architecture graduate's chances of getting a job in Korea. (Govender et al., 2022). The presence of BIM in the formal curriculum can be supported by informal education, such as off-campus courses, which have also proven to be effective in improving BIM skills. This is supported by other research, which found that non-formal training can significantly improve BIM skills in individuals, especially in practical exams (Ramadhan et al., 2022). Course repetition exercises in BIM modeling courses can improve the skills and satisfaction of participants (Hu, 2019). Moreover, building typology is also proved to affect the BIM software used (Dharmatanna & Wijaya, 2024)

In Indonesian context, the use of BIM in professional practice is still relatively rare, limited to state projects and large schools (Irvansyah et al., 2022). Even though there have been many studies conducted in other countries on the application of BIM in the architectural learning process, it is necessary to find out the key aspects of BIM learning in undergraduate architectural education in Indonesia, especially from the perspective of students, as subjects who experience the learning process, as well as using it directly in the design studio. Therefore, this research aims to map the usage of BIM, assess student's ability, and define the challenges and motivations of students in using BIM.

RESEARCH METHODOLOGY

This study used two online questionnaires distributed to undergraduate architecture students. The first questionnaire contained three parts of questions: (1) Students' insight into BIM software; (2) Student's mastery of BIM, and (3) Assessment regarding the use of BIM. In addition, the questionnaire adapted questions from the System Usability Scale (SUS), which is used to assess the usability of a product (Brooke, 1995). SUS has proven to still be relevant for use until now. (Lewis, 2018). More recent researches regarding the use of software are still using these SUS questions, as in the research on the architectural softwares: AutoCAD, Sketchup, and Rhino (Yong et al., 2020) and also studies regarding the perceived usability of evolving technology use in architectural education (Vlachogianni & Tselios, 2022).

The SUS consists of 10 questions on a Likert scale, where in this research, the score ranged from 1 to 5, to simplify the looks in the questionnaire when opened in different types of gadgets. The higher the score, it can be interpreted as higher usability or a more positive statement. The score above 3.33 is considered adequate usability or a positive statement, as in the minimum passing grade score for education (55.5). The conversion from the original score can be seen in figure 1 below.

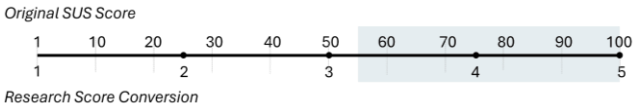


Figure 1. SUS Score Conversion

To be able to capture the respondents' response to the use of BIM, the questions were adapted as shown in Table 1.

Tabel 1. The Adaptation of SUS Questions

No.	SUS Questions and adaptation (in italics)
1	I think that I would like to use this system frequently – *I think I'll use this BIM again*
2	I found the system unnecessarily complex - *I find the BIM software complicated to use*
3	I thought the system was easy to use - *I feel*

	BIM is easy to use
4	I think that I would need the support of a technical person to be able to use this system - *I need help from other people or technicians in using BIM*
5	I found the various functions in this system were well integrated - *I feel the BIM features are well integrated*
6	I thought there was too much inconsistency in this system - *I feel there are many inconsistencies in BIM*
7	I would imagine that most people would learn to use this system very quickly - *I feel others will understand how to use BIM quickly*
8	I found the system very cumbersome to use - *I find the BIM confusing*
9	I felt very confident using the system - *I feel there are no barriers in using BIM*
10	I needed to learn a lot of things before I could get going with this system - *I need to familiarize myself first before using BIM*

The second questionnaire was distributed to respondents who have used BIM, in three time periods: at the beginning, middle, and at the end of the semester. In the questionnaire, students were asked to mention the specifications of the devices they use in the architecture studio, as well as conduct a self-assessment of their ability to operate BIM software. The BIM software asked in this questionnaire were Autodesk Revit and ArchiCAD.

The results of these two questionnaires are then presented in the form of graphs and tables, in order to find the patterns of use and learning of Architecture students.

RESULT AND DISCUSSION

BIM Software Recognition and Usage

The distributed questionnaire was being answered by 229 students across Indonesia, coming from various universities in different semesters, with valid answers. The majority of respondents were from the seventh Semester (35%), followed by second-year students (28.8%).

Moreover, BIM usage is rarely found in the first year students. The usage starts to develop during the second year of the architectural study, which means at the third and fourth semester, as seen in Figure 2. The BIM usage during the final project also decreases, as the final project consists of more variation of building typology.

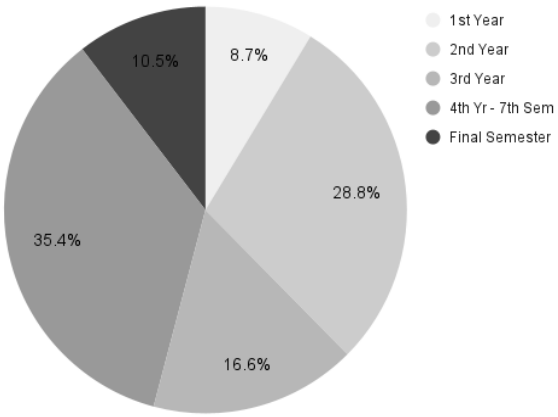


Figure 2. Respondent Profile

As seen in figure 3, in total, 86% (197) of respondents were aware of BIM, but only 60% (136) of respondents had ever used it in the architecture studio process. Further questions of the questionnaire are only answered by the respondents that ever use BIM during their study period.

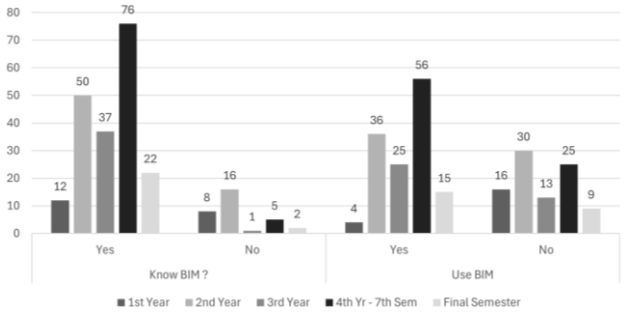


Figure 3. BIM Exposure in Each Semester

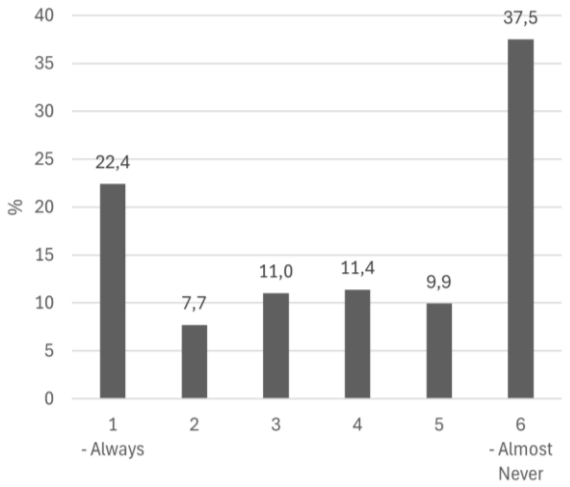


Figure 4. BIM Usage

Figure 4. shows that 30% of the respondents answered that they often, even always use BIM in the design process in the studio, while 47.4% of the respondents still do not really use BIM in their designs. Most of the respondents found BIM to be moderately difficult to learn, as seen from 41.9% of the respondents giving an answer between easy and difficult, on the question about the ease of using BIM, while 34.9% stated that learning BIM was found to be difficult, as shown in Figure 5.

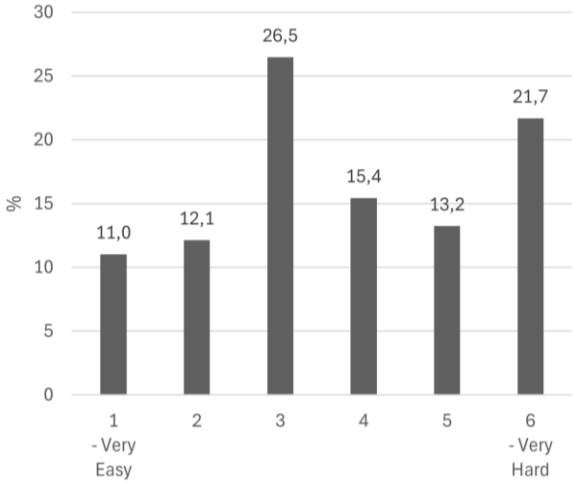


Figure 5. BIM Ease of Learning

Even so, 36% of the respondents stated that they are comfortable learning to use BIM in their projects. This result signifies the fact that even though the students finds hardships, they still willingly study well. This number is also greater than the amount of students that feels inconvenient adapting to use BIM (27%), as in figure 6.

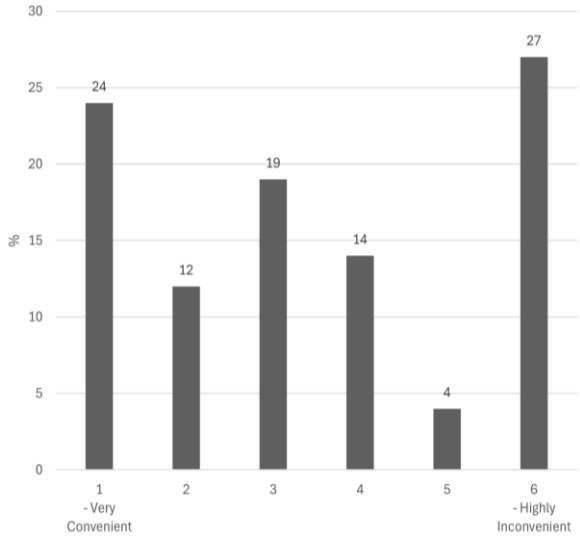


Figure 6. Convenience of BIM Learning

In this first questionnaire, respondents were also asked to do a self assessment on their skill in operating BIM. The result is that 39% of the respondents still have poor skill in BIM. Only 8% of the respondents answer that they are already proficient in using BIM. As in figure 7, 19% of the respondents are already skilled in using BIM, and 18% still have low BIM operating skill.

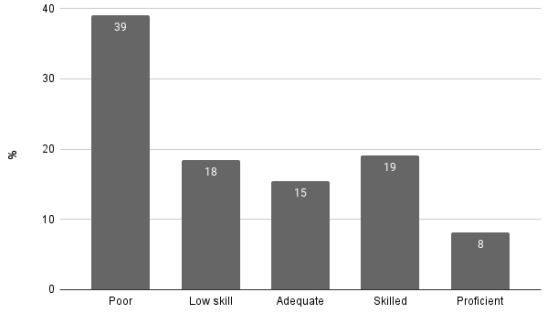


Figure 7. BIM Competency Assessment

The following questionnaire's questions refer to the System Usability Scale (SUS) ten questions, which has been modified accordingly. Respondents felt that the BIM features were fairly consistent, as indicated by the low score on SUS 6 - Inconsistency of BIM Features (2.25/5), and high on SUS 5 - Integration of BIM features (3.86/5). However, respondents indicated barriers in the BIM learning process, which caused them to lack confidence in using BIM. This is characterized by a low score (2.63/5) on SUS 9 - Learning barriers. Respondents also felt quite confused, and felt that others would feel the same way about using BIM (SUS 7 -

Learning process of others - 2.94 / 5, and SUS 8 - Confusion - 2.95 / 5). This is in line with the low score on SUS 3 - Ease of use of BIM (2.78 / 5). However, respondents did not find BIM too complex (SUS 2 - BIM complexity - 3.18 / 5), and it was well integrated (SUS 5 - Integration of BIM features - 3.86 / 5).

Regarding the support of other people or technicians, the score is quite high (SUS 4 - Support of others in learning - 3.80 / 5), meaning that the respondents feel like they do need support on using BIM. This needs can be answered also by joining courses and seeing video tutorials about BIM. Respondents thought that they would continue to use BIM again (SUS 1 - BIM re-use - 3.69 / 5), and recognised the importance of habituation of use for better mastery (SUS 10 - Habituation of use - 4.10 / 5). These SUS results are illustrated in figure 8 below. The respondents faced challenges in learning BIM, but from the results of the questionnaire, they will continue to familiarize themselves with it.

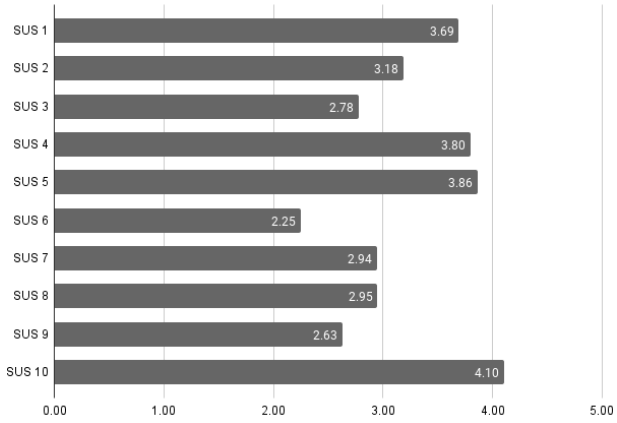
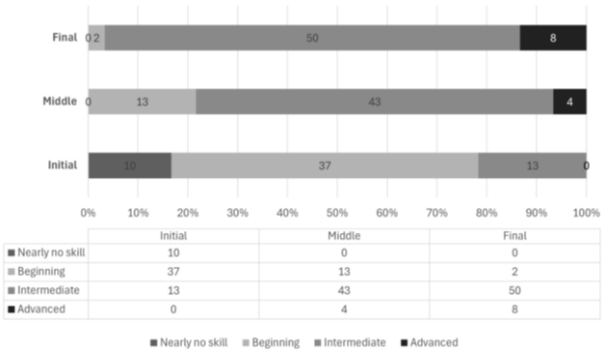


Figure 8. SUS Results

BIM Learning during Architecture Design Studio

The same respondents were observed on their design process using BIM in the design studio they attended. The respondents were asked to fill out the same questionnaire, at three different times: at the beginning, middle, and final of the semester. This questionnaire was distributed to 136 student respondents, and there were 60 respondents with valid, complete responses for each compulsory question, for all three questionnaires.



	Initial	Middle	Final
Nearly no skill	10	0	0
Beginning	37	13	2
Intermediate	13	43	50
Advanced	0	4	8

Figure 9. Learning in one term

Figure 9 shows the results of the students' learning progress. In the beginning, there were still respondents who felt they could not use BIM, but by the midterm survey, all respondents had used BIM in the beginner skill stage. In the final survey, there were 8 respondents (13%) who had mastered the use of BIM. The summary based on the answer combinations are shown in Table 2.

Table 2. Variation in Student Learning Process

Variant	Self Assessed Skill within initial, middle and final questionnaire	%
1	Beginner - Intermediate - Intermediate	40
2	Intermediate - Intermediate - Intermediate	16.67
3	Beginner - Beginner - Intermediate	11.67
4	No skill -Intermediate - Intermediate	8.33
5	No Skill -Beginner - Intermediate	6.67
6	Beginner - Intermediate - Advanced	5
7	Beginner - Advanced -Advanced	3.33
8	Intermediate - Advanced - Advanced	3.33
9	Other	5

From the answers in Table 2, we can map a pattern of all of the respondent's learning processes, as in Figure 10.

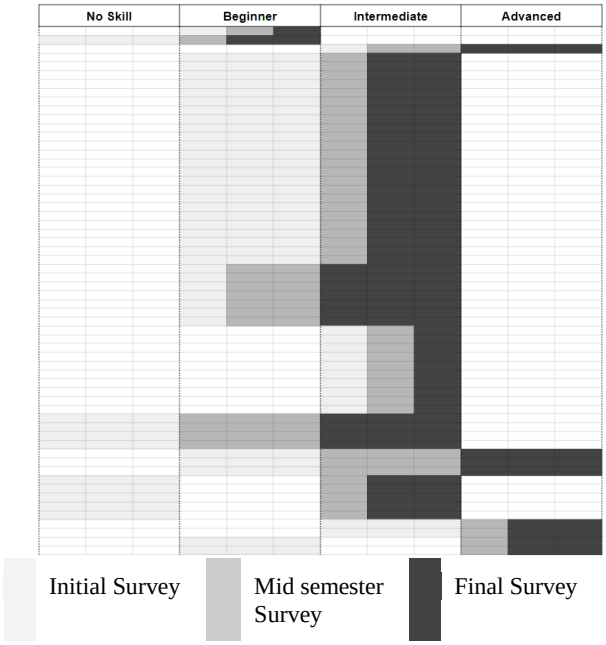


Figure 10. Overview of the BIM Learning Process

From table 2 and figure 10, 83.3% of the respondents ended the semester with intermediate operating skill in BIM. Therefore, in the final semester questionnaire, questions were added regarding the main obstacles in learning BIM from the students' perspective, as well as the motivation.

57% of respondents found that the exploration of many tools in BIM required more time for the learning process, because it was seen as a complicated process. In addition, understanding the concept of how BIM works is also a challenge for students to overcome, especially for 27% of respondents. Devices with adequate specifications were also an issue to be considered, as they can be a barrier to learning, in addition to the lack of learning time and limited skills. The summary of the answers can be seen in figure 11 below.

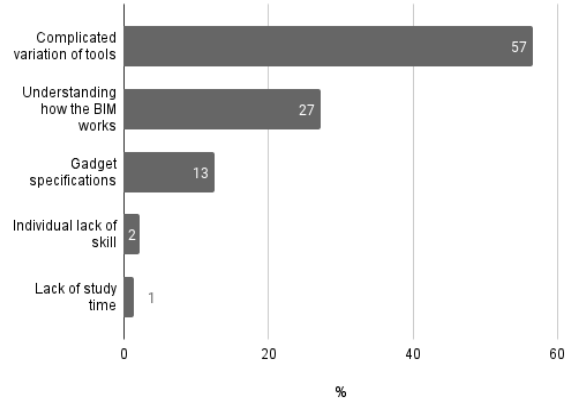


Figure 11. BIM Learning Barriers

As for the motivation on learning BIM, in Figure 12, we can see student's motivation that helps them overcome the barrier. 47% of students understand that BIM is a skill needed in the world of work, so they were motivated to continue using and exploring BIM. BIM features that enable efficient work, which shorten drafting time, also encourage 32% of students to use BIM. Other respondents feels that by using BIM, it is easier to communicate their architectural designs (18%).

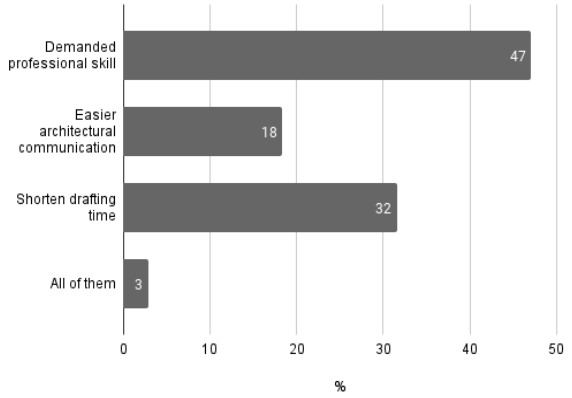


Figure 12. BIM Learning Motivation

CONCLUSION

In Indonesian architecture education curriculum context, BIM is utilized in different semesters, in various course types, ranging from compulsory, integrated in the studio, and optional. From the responses given by the respondents, the use of BIM was rarely found in the first year, and began to increase in the second year, which means during the third and fourth semester. From all of the respondents who had used BIM, there was a fairly clear polarity between respondents who almost always used BIM in their designs (30%), as well as those who only used BIM occasionally (47.4%). Even so, the majority of respondents stated that they felt a moderate level of difficulty in the learning process of using BIM. Respondents also recognised the importance of familiarization with BIM in improving their operational capabilities, as they found the features of BIM to be well integrated, based on the questionnaire adapted from SUS.

The respondents started learning BIM in the semester with a different start, with some respondents already using it, while others were still very new to it, but almost all respondents experienced an increase in their skills by the end of the semester. The majority of

them reached a good level of mastery, and only 8% of the respondents reached the advanced level. Therefore, it can be concluded that learning to use BIM takes more than one semester to become proficient, for the majority of students. This finding could serve as a feedback to the curriculum.

The students also viewed the advanced features and many tools in BIM as the most difficult obstacles to overcome in the process. Therefore, it is suggested that the BIM should be integrated more in the design process, so that the students are exposed to more BIM tools and features.

Motivations that can be emphasized in teaching, so that students remain enthusiastic about the process of using BIM are its usefulness in the world of work, as well as the possible time efficiency gained by using BIM.

Because it takes time for habituation, the use of BIM can be optimized not only in design studios or elective courses with a focus on learning the features of BIM, but also in applicable elective courses such as cultural heritage preservation, which requires students to model according to existing conditions, while directly using the BIM features that have been learned, while increasing the level of use of BIM to a higher level to collaborate and calculate sustainability aspects in a project.

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