Understanding Civil Engineering and Architectural Engineering Students' Perceptions about BIM Practices

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Abstract: The use of BIM within construction industry is experiencing development. However, the development of BIM in Indonesia is still very limited. One of the inhibiting factors in the development of BIM is the inadequate availability of BIM specialists and professionals in the construction industry so that an active role of students is needed as the main target in meeting the needs of the construction industry in Indonesia. This research was conducted to analyze the perceptions of students of the Sriwijaya University in the civil engineering and architecture study programs regarding perceptions of knowledge, benefits, adoption, and development of BIM. This study used a quantitative approach. Data collection was carried out using a questionnaire. It was stated that 'BIM technology and concepts are important for students to learn' was to be the highest rank with an average score of 4.70 for Civil Engineering and 4.56 for architecture students. The result shows that the benefits of BIM that influence the most in the construction industry are to improve the quality of construction and enhance design visualization. The most significant driving factor on the development and adoption of BIM is education and training on using BIM software. In addition, the most significant inhibiting factors that influence the development and adoption of BIM are lack of education or training on the use of BIM and lack of knowledge on how to implement BIM software.

Keywords: Building Information Modeling (BIM), civil engineering, architecture, construction industry, perception

INTRODUCTION

Construction technology is at a development stage with rapid progress. One of the technologies in the Architecture, Engineering and Construction (AEC) sector that is developing and has quite a lot of enthusiasts in the world is Building Information Modeling (BIM). BIM is defined as a digital representation of 3D modeling that could facilitate a precise modeling of a building system [1]. The concept of BIM is not just a software technology, but also as a holistic process that represents the attribute of a building component [2]. Based on the Regulation of the Minister of Public Works and Public Housing No. 22/2018 concerning State Building Construction [3], the buildings with an area of more than 2,000 m^2 are required to use BIM. It is evident that the government has contributed to the development of technological innovation in the world of construction.

The benefits of using BIM in construction projects as a means of communication among stakeholders [4]. The results showed that BIM can be effectively used as a means of communication among stakeholders to improve collaboration and information sharing. A study of [5] highlighted the use of BIM at the design stage. It was found that BIM software enabled the architect and engineer to modify building components during modeling which eventually can help the owners for decision making related to incurred costs and work progress. Mieslenna and Wibowo [6] studied the application of BIM in the Indonesian construction industry based on the user's perspective. The results showed that the benefits of BIM were to control the

construction projects, estimate costs, avoid rework and save human resources. The inhibiting factors for BIM adoption are considerable investment needs, availability of BIM specialists, sustainable training needs, and transition of work culture from conventional to BIM. Ramadhani [7] on the perception of university of UPI students about the use of BIM in the era of industrial revolution 4.0 stated that the level of knowledge of UPI students about the existence of BIM fell into a very high category.

The use of BIM in construction projects provides benefits to improve the quality of construction products and enables more sustainable building designs [8]. A study by [9] regarding the comparison of the BIM method with conventional methods, it was said that BIM can improve scheduling accuracy by 50%, improve the accuracy of cost estimation by 52.25% and reduce human resources used by 26.66%. It has been proved that the role of BIM to make the construction world in Indonesia gain more attention. However, the development of BIM in Indonesia is still very limited and in slow progress [2]. A study of [10] investigated students' perception on BIM application using a survey for construction management students. This study found that most students agreed to incorporate the BIM into construction management course program. The students were also aware of the importance of BIM education to get a job within construction industry. BIM adoption within AEC industry in Indonesia and found that the lack of awareness and understanding about BIM could impede its adoption [11].

According to [6], the inhibiting factors in the adoption of BIM and the development of BIM in Indonesia are the transition of work culture from conventional to BIM, the need for large investments, availability of specialists or professionals in BIM, as well as the needs for continuous training. Furthermore, one of the inhibiting factors in the development of BIM is the availability of inadequate BIM specialists and professionals in the construction industry. Therefore, an active role of students is required as the main target in meeting the needs of the construction industry in Indonesia. The students in universities need to gain basic knowledge about BIM technology and engaged in the development of BIM as BIM continues to evolve. This study was conducted to analyze the perception of students of civil engineering and architecture study program in the University of Sriwijaya in terms of knowledge, benefits, and adoption of BIM as well as perceptions about the development of BIM. It is perceived that the students at University of Sriwijaya have had the basic knowledge regarding BIM knowledge since there have been some seminars or trainings held for the last 2 years in 2019-2021.

METHODOLOGY

This research used a quantitative approach. Data collection was carried out through the results of a questionnaire in the form of a Google form. 240 students in the year of 2017 to 2019 at Civil Engineering and Architecture program of Sriwijaya University were involved in this research. Because the students at the school year of 2017-2019 have participated in BIM seminars and trainings held in Civil Engineering Department, meanwhile students in the year of 2020-2021 had not joined the programs.

Descriptive analysis was conducted to rank the level of importance of the identified variables based on students' perceptions. Likert scale was used to assess for the variables based on previous research as seen in Table 1. The data processing of the questionnaire results was carried out using SPSS programs. The criteria in the validity test used an error rate of 5%. For the validity test, if $r_{statistics}$ is higher than $r_{critical}$ then the data obtained is declared valid. Conversely, if $r_{statistics}$ is smaller than $r_{critical}$ then the data obtained is declared invalid. The criteria for reliability tests are Cronbach alpha values over 0.6 which means they have a strong relationship.

TABLE 1. Research Variable from Previous Research

Sources	Ref [9]	Ref [4]	Ref [5]	Ref [12]	Ref [6]	Ref [7]	Ref [13]
Basic Understanding about BIM							
Knowledge of the concept of BIM in the world of construction	-	-	-	-	-	√	-
Construction trends in Indonesia	-	-	-	-	√	-	-
Interest in knowing and learning BIM	-	-	-	-	-	√	-
The importance of learning BIM	-	-	√	-	-	-	-
Optimistic about BIM development	-	-	√	-	-	√	
Benefits of using BIM							
Increase productivity	-	-	√	-	-	-	√
Supports non-face-to-face analysis	-	-	√	-	-	-	-
Reduce design changes in the construction phase	-	-		-	√	-	-
Support decision making	-	-	√	-	-	-	-

	C1	C2	C3	C4	C5	C6	C7
Improve scheduling and planning accuracy	√	-	-	-	-	-	√
Improve the accuracy of project cost estimates	√	-	-	-	-	-	√
Accelerate project execution	√	-	√	-	-	-	√
Improve communication of parties involved in the project	-	√	-	-	√	-	-
Improve the quality of construction in Indonesia	√	√	√	√	√	√	√
Realization of design ideas through 3D models	-	-	-	-	-	-	√
Improve design quality	√	-	-	-	√	-	-
Sustainable design	-	√	-	-	-	-	-
Targeted visualizations that reflect planned virtual state	-	-	-	-	-	-	√
BIM application or software usage							
Knowledge of various BIM software	-	-	-	-	-	√	√
BIM software used	-	-	-	-	-	-	√
Support or encouragement in the development and adoption of BIM							
Industry awareness or market trend for BIM implementation	-	-	-	-	√	-	-
Government regulations on BIM adoption	-	-	√	-	-	-	-
The role of universities in encouraging students to study BIM	-	-	√	-	-	-	-
Seminar on BIM technology	-	-	-	-	√	-	-
BIM software training	-	-	-	-	√	-	-
Barriers in the development and adoption of BIM							
Awareness of BIM implementation by stakeholders	-	-	-	√	-	-	-
Knowledge to implement BIM	-	-	-	√	-	-	-
Transition of work culture from conventional and CAD programs to BIM	-	-	-	√	√	-	-
Awareness of the benefits of BIM	-	-	-	√	-	-	-
High cost	√	-	-	√	-	-	-
PC Specifications	√	-	-	√	-	-	-
Government support	-	-	√	√	-	-	-
Minimal availability of BIM professionals	-	-	-	√	-	-	-
Availability of education or training on BIM	-	-	-	-	√	-	-
Interest in learning new technologies	-	-	-	√	-	-	-

RESULT AND DISCUSSION

The respondent data were used to determine the characteristics of civil engineering and architecture students of Sriwijaya University based on their department, gender and class year as seen in Table 2 and 3 below.

TABLE 2. Characteristics of Respondents

Department	Number of Respondents	Percentage (%)
Civil Engineering	153	64
Architecture	87	36
Total	240	100

TABLE 3. Characteristics of Respondents by Gender and Class Year

Gender	Civil Engineering		Architecture Engineering	
	Number of Respondents	Percentage (%)	Number of Respondents	Percentage (%)
Men	87	57	37	43
Women	66	43	50	57
Total	153	100	87	100
Class Year				
2017	53	35	26	30
2018	46	30	29	33
2019	54	35	32	37
Total	153	100	87	100

TABLE 4. Variables used in this research

Variable	Question Item (QI)	Code
Basic Understanding of BIM	Are you familiar with BIM technology and concepts?	P1
	Do you think BIM is one of the construction trends in Indonesia today?	P2
	Do you think the development of BIM technology and concepts are interesting to follow and learn?	P3
	Do you think BIM technology and concepts are important for students to learn?	P4
	Do you think the development and adoption of BIM will continue to increase?	P5
Benefits of BIM	Increase work productivity in construction projects	M1
	Supports non-face-to-face analysis	M2
	Reduce design changes in the construction phase	M3
	Improving the management and operation of development to support decision making on matters relating to buildings	M4
	Improve project scheduling accuracy	M5
	Improve the accuracy of project cost estimates	M6
	Accelerate project execution and reduce costs due to more mature planning	M7
	Improving communication of parties involved in the project	M8
	Creating and improving the quality of construction in Indonesia	M9
	Increase job productivity	M1
Benefits of BIM	Improving the realization of design ideas through 3D models	M2
	Supporting the work without face-to-face	M3
	Improved design quality (reduce errors / redesign and manage design changes)	M4
	Improve sustainable design and design efficiency	M5
	Reduce design changes in the construction phase	M6
	Improving the management and operation of development to support decision making on matters relating to buildings	M7
	Improving communication of parties involved in the project	M8
	Make visualizations more targeted and reflect planned virtual circumstances	M9
Use of BIM applications or software	Knowledge of various BIM software	S1
	BIM software used	S2
	Industry awareness or market trend for BIM implementation	F1
Support or encouragement in the development and adoption of BIM	Regulations issued by the government on the mandatory use of BIM for buildings over 2000 m^2	F2
	Universities that encourage students to study BIM	F3
	There is a seminar discussing BIM technology	F4
	Training to learn BIM software	F5
Barriers to the development and adoption of BIM	Lack of awareness of BIM implementation by stakeholders	H1
	Lack of knowledge on how to implement BIM software	H2
	Professionals think that current CAD systems and other conventional programs have met the needs of designing and performing work and completing projects efficiently	H3
	Lack of awareness about the benefits of BIM	H4
	High cost to invest in BIM software	H5
	Adequate PC specifications (likely expensive) are required to study BIM	H6
	Lack of government support to fully implement BIM	H7
	Lack of skilled architects/engineers in the use of BIM	H8
	Lack of education or training on the use of BIM, whether in universities, government, or private training centers	H9
	Reluctance to learn new technologies due to education culture and already familiar with the programs used	H10

Basic Understanding of BIM Knowledge

Based on Table 5, it was stated that 'BIM technology and concepts are important for students to learn' was at the highest rank with an average score of 4.70 for Civil Engineering and 4.56 for architecture students. This indicates that most students strongly agree with the perception about BIM technology and concept. The number of students who strongly agree with this perception means that civil engineering and architecture students already realize BIM is an important technology in the construction industry. The lack of engineers in the construction industry who understand about BIM indicates the urgency for students to learn BIM. Before entering the world of work, it is essential for students to have basic knowledge gained in the university and get better prepared to enter the world of work. The students have positive perceptions related to the basic understanding of BIM in terms of the needs to adopt BIM and to incorporate BIM into curriculum [14]. Due to the substantial and rapid demand of BIM within the construction industry, there is

an urgency to implement BIM starting at the university level into its real practices. The study of Ramadhani [7] also showed that students have been familiar with the BIM term, and have basic knowledge of BIM. As it is perceived that BIM knowledge has not been incorporated in the curriculum, and many students learn BIM out of their course class. Thus, the students learn BIM through their individual learning.

TABLE 5. Basic Understanding about BIM Knowledge

Code	Question Item	Mean Value of Civil Engineering Students	Mean Value of Architecture Students
P4	BIM technology and concepts are important for students to learn	4.70	4.56
P3	The development of BIM technology and concepts are interesting to follow and learn	4.64	4.47
P5	The development and adoption of BIM will continue to increase	4.54	4.39
P2	BIM is one of the construction trends in Indonesia today	4.09	3.97
P1	BIM technology and concepts are familiar to you	3.57	3.49

Benefits of BIM

Based on Table 6, the civil engineering students perceived the most important benefits of BIM is to create and to improve the quality of construction in Indonesia with an mean value of 4.54. Prior to BIM technology, the project construction is mostly dominated by using conventional methods with a design in the form of 2D. Although the conventional methods are still used nowadays but conventional methods are not carried out in a coordinated and integrated manner. However, the concept of BIM can be conducted in a coordinated and integrated process. The collaboration and integration with BIM is able to facilitate construction work from the planning stage to the maintenance of a building construction. BIM can visualize the construction design in 3D not only in real time, but also a variety of information on construction such as materials, precision, costs that will certainly improve the communication of related parties. This indicates the concept of BIM to improve the quality of construction in Indonesia. The architecture students perceived the most significant benefit of BIM is to make visualizations more efficiently and virtually as seen in Table 10. Since architects mainly focused on design, they tend to highlight on visualization of drawings. This suggests BIM could indicate the real world of visualization. The design using BIM can be performed more effectively since BIM offers accuracy, more information with minimum errors. The rank of BIM benefit for civil engineering and architecture students can be seen in Table 6 and 7.

TABLE 6. BIM Benefit based on Civil Engineering Students

Code	Question Item	Mean	Rank
M9	Creating and improving the quality of construction in Indonesia	4.54	1
M1	Increase work productivity in construction projects	4.42	2
M6	Improve the accuracy of project cost estimates	4.38	3
M4	Improving the management and operation of development to support decision making on matters relating to buildings	4.34	4
M5	Improve project scheduling accuracy	4.31	5
M7	Accelerate project execution and reduce costs due to more mature planning	4.29	6
M2	Supports non-face-to-face analysis	4.05	7
M8	Improving communication of parties involved in the project	4.01	8
M3	Reduce design changes in the construction phase	3.88	9

TABLE 7. BIM Benefits based on Architecture Students

Code	Question Item	Mean	Rank
M9	Make visualizations more targeted and reflect planned virtual circumstances	4.45	1
M2	Improving the realization of design ideas through 3D models	4.44	2
M5	Improve sustainable design and design efficiency	4.33	3

M4	Improved design quality (reduce errors / redesign and manage design changes)	4.32	4
M1	Increase job productivity	4.31	5
M7	Improving the management and operation of development to support decision making on matters relating to buildings	4.13	6
M8	Improving communication of parties involved in the project	3.95	7
M6	Reduce design changes in the construction phase	3.86	8
M3	Supporting the work without face-to-face	3.82	9

Use of BIM applications or software

This section presented the number of students who have known the types of BIM software as well as the BIM software commonly used by the students. Figure 1 displayed that most students both civil engineering and architecture students are familiar with Sketchup, Tekla, ArchiCAD, Revit as BIM software. Meanwhile, Figure 2 indicated that most student also have used BIM software such as Sketchup, Tekla, ArchiCAD, Revit during their study in the university. It can also be seen that the most used and known software by students is Sketchup while others are moderately used. The students also identified other software that they get familiar with but not included in types of BIM software.
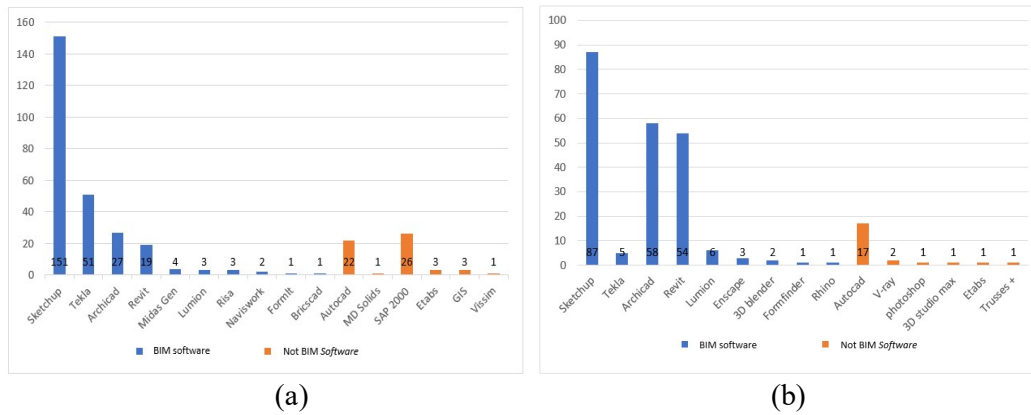

(a)   (b)

FIGURE 1. Software that mostly known (a) Civil Engineering Students (b) Architecture
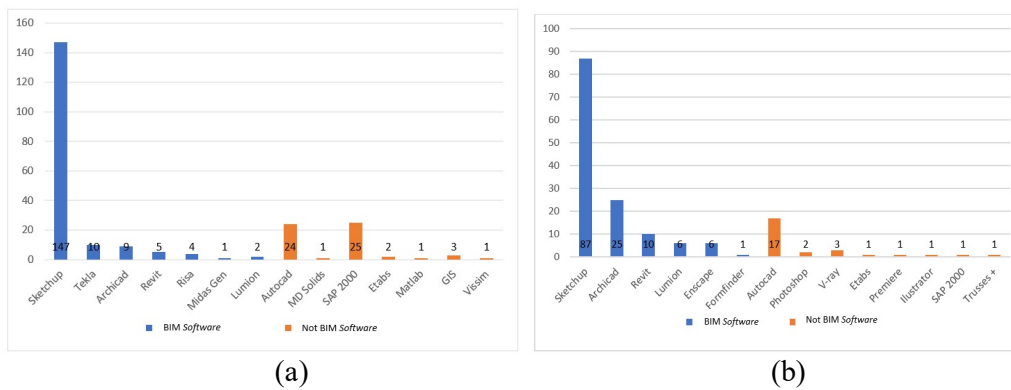

(a)   (b)

FIGURE 2. Software that mostly used (a) Civil Engineering Students (b) Architecture

BIM Development and Adoption

Table 8 and 9 presented perception about the development and adoption of BIM among students of Civil Engineering and architecture. Based on the results analysis, it was found that a need of training to learn

BIM software was the most influential supporting factors in the development and adoption of BIM both for civil engineering and architecture students. BIM software training is necessary for students to operate and understand BIM software well so that the development and adoption of BIM increases. It is expected that training students can also improve their ability and qualifications to compete in the world of work.

TABEL 8. Ranking of BIM Development and Adoption to Civil Engineering Students

Code	Question Item	Mean
F5	Training to learn BIM software	4.62
F4	A seminar discussing BIM technology	4.42
F3	Universities that encourage students to study BIM	4.35
F2	Regulations issued by the government on the mandatory use of BIM for buildings over 2000 m^2	4.08
F1	Industry awareness or market trend for BIM implementation	3.88

TABEL 9. Ranking of BIM Development and Adoption to Architecture Students

Code	Question Item	Mean
F5	Training to learn BIM software	4.55
F3	Universities that encourage students to study BIM	4.20
F4	A seminar discussing BIM technology	4.20
F1	Industry awareness or market trend for BIM implementation	3.99
F2	Regulations issued by the government on the mandatory use of BIM for buildings over 2000 m^2	3.98

Benefits of BIM

This section discussed the students' perception on the barriers of BIM development and adoption. As seen in Table 10 and 11, it was found that the lack of education or training on the use of BIM has become the major barrier to adopt BIM among students. The poor education and training about BIM could result in poor knowledge about BIM and inability to operate BIM technology. It is inevitable that to implement BIM software certainly requires knowledge to operate. The software cannot run properly and give benefits if the user is unable to use the software. Therefore, training on BIM is required to improve the knowledge and ability of students to use BIM. In terms of barriers, similar study of Wong and Gray [15] indicated that the lack of training and education had become the most significant barrier towards BIM adoption not only within university students but also in construction industry. There is a need to overcome the barriers to increase the productivity and efficiency of the construction industry through BIM education and training among stakeholders.

TABEL 10. Ranking Data on Civil Engineering Students

Code	Question Item	Mean
H9	Lack of education or training on the use of BIM, whether in universities, government, or private training centers	4.42
H2	Lack of knowledge on how to implement BIM software	4.41
H6	Adequate PC specifications (likely expensive) are required to study BIM	4.39
H8	Lack of skilled Architects/Engineers in the use of BIM	4.29
H10	Reluctance to learn new technologies due to education culture and already familiar with the programs used	4.24
H4	Lack of awareness about the benefits of BIM	4.23
H7	Lack of government support to fully implement BIM	4.16
H5	It takes a high cost to buy BIM software	4.15
H3	Professionals think that current CAD systems and other conventional programs have met the needs of designing and performing work and completing projects efficiently	4.05
H1	Lack of awareness of BIM implementation by stakeholders	4.00

TABEL 11. Ranking Data on Architecture Students

Code	Question Item	Mean
H2	Lack of knowledge on how to implement BIM software	4.43
H6	Adequate PC specifications (likely expensive) are required to study BIM	4.41

H9	Lack of education or training on the use of BIM, whether in universities, government, or private training centers	4.41
H7	Lack of government support to fully implement BIM	4.29
H4	Lack of awareness about the benefits of BIM	4.23
H5	It takes a high cost to buy BIM software	4.23
H1	Lack of awareness of BIM implementation by stakeholders	4.08
H8	Lack of Skilled Architects/Engineers in the use of BIM	4.00
H10	Reluctance to learn new technologies due to education culture and already familiar with the programs used	4.00
H3	Professionals think that current CAD systems and other conventional programs have met the needs of designing and performing work and completing projects efficiently	3.83

CONCLUSION

Based on the analysis, it was concluded that 'BIM technology and concepts are important for students to learn' was at the highest rank with an Mean value of 4.70 for Civil Engineering and 4.56 for architecture students. This indicates that most students strongly agree with the perception about BIM technology and concept. The civil engineering students perceived the most important benefits of BIM is to create and to improve the quality of construction in Indonesia with an Mean value of 4.54. Prior to BIM technology, the project construction is mostly dominated by using conventional methods with a design in the form of 2D. Although the conventional methods are still used nowadays. However, the conventional methods are not carried out in a coordinated and integrated manner.

The need of training to learn BIM software was the most influential supporting factors in the development and adoption of BIM both for civil engineering and architecture students. BIM software training is necessary for students to operate and understand BIM software well so that the development and adoption of BIM could increase. It is expected that training students can also improve their ability and qualifications to compete in the world of work. It was also found that the lack of education or training on the use of BIM has become the major barrier to adopt BIM among the students.

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