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Research paper

Analysis of Student Experience in Using Building Information Modeling (BIM) to Understand the Concept of Steel Structure

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ABSTRACT

Background: BIM is a digital program or software that was created to transform the conventional construction world into a digital and integrated construction world to facilitate development work. This study aims to determine the experience of students in using BIM to understand the concept of Steel Structures for students of classes 2020 & 2021.
Methods: This research uses a qualitative approach with thematic analysis techniques, whose data collection uses BIM test scores and Steel Structure II scores. Data collection techniques were carried out by interviewing 10 students who could do the BIM test and get high Steel Structure scores. Thematic analysis using ChatGPT version 4.
Results: The results show that there are 6 themes in the experience of students in using BIM to understand the concept of Steel Structure. The first theme is the general experience with BIM. The second theme is the benefits of using BIM for Steel Structures. The third theme was the challenges in using BIM, and students experienced initial difficulties in understanding BIM. The fourth theme was the role of BIM in improving understanding of Steel Structures. The fifth theme is the perception of using BIM in civil engineering learning. The sixth theme is suggestions for improving the use of BIM.
Conclusion: This research concludes that the use of BIM in learning Steel Structure is very useful to deepen students' understanding of the concept of Steel Structure.

INTRODUCTION

Building Information Modeling (BIM) is an information system that processes inputs into information in the form of building modeling as a tool in the decision-making process at every stage of a construction project (Hutama & Sekarsari, 2018). In this case, the application of BIM also changes conventional patterns to be more integrated and collaborative (Nugrahini & Permana, 2020). Therefore, it can be said that BIM is a digital program or software that was created to change the conventional construction world into a digital and integrated construction world to facilitate development work. Based on Government Regulation (PP) Number 16 of 2021, which states that the use of BIM must be applied at least up to the fifth dimension (5D) for the method of implementing technology-intensive building construction. Meanwhile, it is mandatory to use BIM up to the eighth dimension (8D) for capital-intensive building construction. The application of BIM in Indonesia is still relatively low and is still at 38% (Puspita & Patriotika, 2021). The majority of consultants in Indonesia still use BIM level 0 and BIM level 1 (Setiawan, 2022). In addition, in 2016, the Ministry of PUPR, through Balitbang (Research and Development Agency) issued an Indonesian digital construction roadmap or BIM application roadmap with four phases, namely the adoption phase, digitization phase, collaboration phase, and integration phase. (Heryanto & Subroto, 2020).

This encourages educational units engaged in the realm of construction to produce graduates who are proficient in mastering BIM. Educational institutions, including universities, have an obligation to produce quality graduates (Sari & Sylvia, 2020). Building Engineering Education (PTB) Faculty of Engineering UNJ is one of the educational institutions that teaches construction science to its students. In facing the world of construction in the era of the Industrial Revolution 4.0, PTB students also need to be equipped with knowledge and understanding related to the application of BIM. This is an opportunity for lecturers to prepare students to face technological sophistication in order to compete in the new era (Setiami & Maulana, 2021). One of the courses at Jakarta State University that uses BIM in the learning process is Steel Structure.

Steel Structure is a course that provides knowledge about steel as one of the materials for building construction, along with planning and basic knowledge for Steel Structure planning. Steel Structure is one of the compulsory courses in the UNJ Building Engineering Education study program, with a weight of 2 credits. Broadly speaking, this course is a continuation of the Steel Structure 1 course, which studies the planning of building structures using steel materials, including: steel profiles, tensile bar planning, steel connection planning, compression bar planning, plate and beam planning. Project assignments given by lecturers to students in this course learning are require to use of the BIM application, while BIM learning/training for students is not sufficient, so many students are not yet able to operate BIM. This is shown in preliminary research conducted on 45 students of the UNJ Building Engineering Education study program, where 2.2% of students have very poor knowledge of BIM, 37.8% of students have less knowledge, and 31.1% have sufficient.

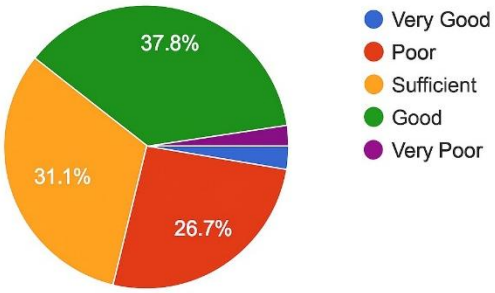

Figure 1. Knowledge of Building Information Modeling (BIM) Before Starting the Steel Structure 2 Course

Based on research conducted by Hanifah (2024), it reveals that numerous obstacles exist to the use of BIM due to the lack of knowledge and inadequate implementation of BIM among contractors in Indonesia, resulting in BIM not running optimally and comprehensively. Therefore, there is a link between knowledge and one's ability to implement BIM. This means that the lack of student knowledge about BIM causes students to be less able to operate BIM, so that during learning, students will find it difficult to integrate BIM into the theory taught. This can also be seen in the results of preliminary research that has been conducted, where 48.9% of students have difficulty integrating BIM into the theory taught in the Steel Structure course.

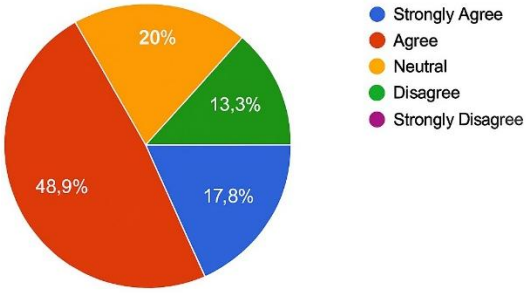

Figure 2. Difficulty in Integrating BIM with the Theory Taught in the Steel Structure 2 Course

In the implementation of BIM learning, it is important to explore the readiness to produce more effective learning. One of the things that must be prepared in the development of BIM learning implementation in the field of technology is learning facilities consisting of software, hardware, and physical infrastructure of BIM learning spaces. Based on research conducted by Putri et al. (2023) in the UNJ Building Engineering Education study program, there is no provision of BIM software and a lack of computer device specifications (hardware) in the UNJ digital drawing laboratory. This is in line with preliminary research that has been conducted, where 42.2% of students feel that the support provided by lecturers in using BIM is not sufficient to help students understand the material, as shown in the diagram below (Figure 3).

This preliminary study is also supported by the final grades obtained by students in the Steel Structure course. Where the majority of students obtained B and C- grades, while only a small percentage achieved A or A- grades. This shows that there is still a gap in the understanding and application of steel design concepts. With the following diagram (Figure 4).

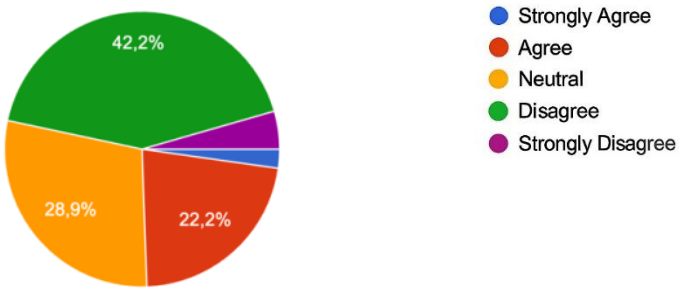

Figure 3. Lecturer Support in Steel Structure 2 Course

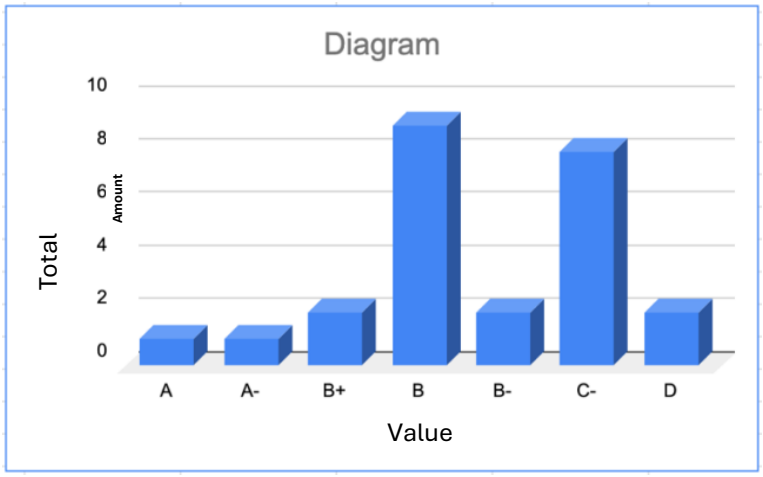

Figure 4. Gaps in Understanding and Application of Steel Design Concepts

Research on BIM in universities has been done before, one of which is research conducted by Setiawan (2022) entitled “Study of BIM Learning in Higher Education”. This research examines the application of BIM in higher education. Following its title, this research aims to examine the application of BIM in learning in higher education. The results of this study suggest that BIM learning in higher education is needed to meet the needs of today's construction world. The relevance of this research is that both examine BIM learning in higher education, but the difference is that the research conducted by researchers only focuses on BIM learning at UNJ, precisely in the Steel Structure course.

Furthermore, there is a study conducted by Alrizqi & Fazri (2023) that evaluates the use of BIM as one of the learning methods on campus. The results of this study state that there are advantages and disadvantages to the application of BIM in learning. The relevance of this research is that it has the same goal. Another study by Putri et al. (2023) entitled “Readiness to Implement Building Information Modeling (BIM) Learning in Building Engineering Education Study Programs at Jakarta State University and Indonesian Education University”. Research by Anisa (2024) aims to find the influence of the use of BIM technology in the planning and construction process, while in the research to be conducted, the variable studied is the mastery of skills on learning success.

The use of BIM in assignments in the Steel Structure course is a form of preparing students not only with theory, but also with practical skills that are relevant to current trends in the construction world. However, is the application of BIM in the Steel Structure course effective, and how can these BIM skills support students' academic success? Based on the explanations

above, it is concluded that the application of BIM in education, especially in Steel Structure courses, is very important, but it is also important to know whether the application of BIM in Steel Structure courses is effective. Therefore, an analysis is needed to find out whether there is an effect of mastering BIM skills on student skills in Steel Structure courses in the UNJ Building Engineering Education study program.

METHODS

This research uses qualitative methods with descriptive research types. The research design was carried out by giving tests to 35 students from classes 2020 and 2021 who had completed the Steel Structure II course. This aims to determine informants who will be interviewed. They were given 180 minutes to complete the BIM test questions that had been made. The research subjects were 2020 and 2021 batch students who were able to complete the BIM test conducted by the researcher, then they were also representatives who got the highest score in the Steel Structure II course. So that from 35 students, a total of 10 students were obtained. In this study, the expert validation test was carried out by giving a series of questions to experts to test the validity of the questions by Mr. A P, S.T., M.T. and Mrs. N A, S.Pd., M. Sc. The data analysis procedure uses the Miles and Huberman model (1984).

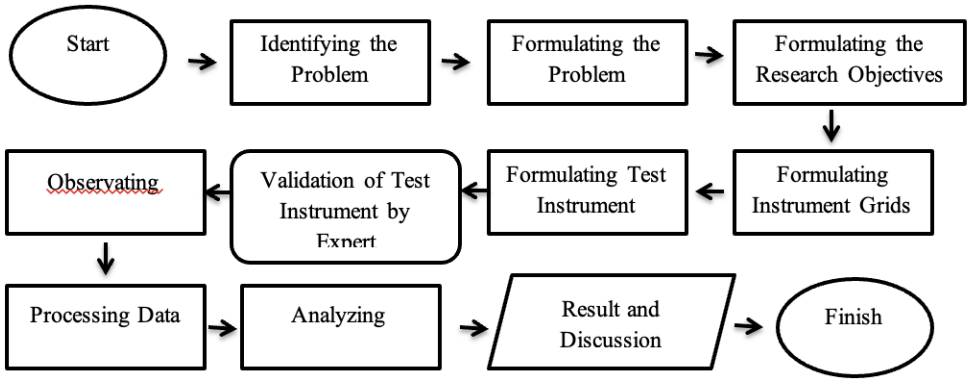

Figure 5. Research Methodology Steps

Data collection techniques and procedures were carried out by interview, with a list of questions regarding :

1. General Experience With BIM.
2. Benefits of Using BIM for Steel Structures.
3. Challenges in Using BIM.
4. Role of BIM in Improving Understanding of Steel Structures.
5. Perception towards the Use of BIM in Civil Engineering Learning.
6. Suggestions for Improving the Use of BIM.

RESULTS AND DISCUSSION

1. Research Results

A. General Experience With BIM

Based on the results of thematic analysis, open coding and axial coding are obtained as follows.

Table 1.
Thematic Analysis Results of Common Experience with BIM

No.	Open Coding	Axial Coding
1.	1. Their experience using BIM	1. Experience of using BIM
	2. Type of software used, main features of BIM	2. Software used
	3. Challenges faced, benefits of using BIM	3. Main features of BIM
	4. Relevance of learning with BIM in career preparation	4. Benefits of using BIM

Building Information Modeling (BIM) is one of them, introduced through the experience of large assignments given by lecturers through learning Steel Structure courses. BIM technology also has a function as a link between those who are relevant to the world of the construction industry in the future. BIM software used in Steel Structure, such as Revit, E-TABS, and SAP, serves as the main tool in the design and analysis of Steel Structure. These applications can also improve students' understanding of structural elements. BIM is not only beneficial to academic learning, but also provides practical skills that are essential for the world of work, leading to student readiness, in facing professional challenges. In the face of these challenges, however, BIM provides an opportunity to overcome these challenges, one of which is the large Steel Structure assignment, as well as relevant theory to explore the software used.

B. Benefit of Using BIM for Steel Structure

Based on the results of thematic analysis, open coding and axial coding are obtained as follows.

Table 2.
Thematic Analysis Results of the Benefits of Using BIM for Steel Structures

No.	Open Coding	Axial Coding
1.	1. Time efficiency	1. Time efficiency and accuracy
	2. Better visualization	2. 3D visualization and understanding of Steel Structure
	3. Reduction of manual calculation errors and improved understanding of concepts	3. Use of BIM software for design and analysis
	4. Long-term skill development	4. Skills development and career opportunities
	5. Wider career opportunities thanks to the use of BIM.	5. Advantages of BIM software over conventional methods.

The use of Building Information Modeling (BIM) in learning steel structure design and analysis provides many advantages, both in terms of efficiency and accuracy. BIM allows students to perform calculations and modeling of steel structures more quickly and precisely, thus improving time efficiency as well as achieving more accurate results. With 3D visualization, students can understand steel structures more clearly and in detail, providing deeper insights compared to the use of traditional 2D drawings. In addition, the application of BIM technology in learning brings significant changes in the way of learning, allowing students to engage more actively and deeply in the design and analysis process. The use of BIM also helps students develop skills relevant to the needs of the construction industry, opening up wider career opportunities.

Compared to conventional manual methods, BIM offers advantages in terms of speed, accuracy, and convenience, which certainly speed up and simplify the design and analysis process of steel structures. Based on the results of interviews with Building Engineering Education students with high BIM test scores, also argued that: “BIM is very helpful, especially in terms of time and energy. In terms of time, I can quickly get the data I need regarding loading analysis and others using BIM software. Whereas using conventional methods takes a long time because we have to calculate the volume, calculate various materials, so in terms of time, it is very long. Maybe that's all for the use of BIM”. (D,Wawancara/12/02/2025).

C. Challenges in Using BIM

Based on the results of thematic analysis, open coding and axial coding are obtained as follows.

Table 3.
Thematic Analysis Results of Challenges in Using BIM

No.	Open Coding	Axial Coding
1.	1. General Difficulties 2. Technical Constraints 3. Complexity of BIM Software 4. Classroom Materials and Learning Support 5. Challenges in the Learning Process	1. General Difficulties and Technical Constraints 2. Constraints in Using BIM Software 3. Classroom Materials and Learning Support 4. Challenges in the Learning Process

One of the challenges in learning and using Building Information Modeling (BIM) among students is the initial difficulty in understanding this technology, which is exacerbated by limited classroom materials and a lack of adequate support. This was also felt by one of the Building Engineering Education students who argued that: “Honestly, I have difficulties because this is my first experience, so that's what I explained earlier so I have to learn a lot more independently to have free time to learn and to understand how to use the laptop that we use. Sometimes it is not adequate and constrained, it can be slow, or some applications cannot be downloaded. Then, another obstacle is the learning resources. So the learning resources that we use, we have to look for ourselves, independently, then look for other sources” (S, Interview/11/02/2025).

However, self-learning is the main solution, although it requires considerable time and effort. In addition, technical constraints, such as inadequate hardware, as well as other issues, such as slow performance and difficulty in downloading software, further exacerbate the BIM learning experience. The complexity of the BIM software is also a big challenge, with students struggling to master various complicated features without sufficient guidance. To overcome the limited materials available, students rely heavily on self-learning, seeking external tutorials, and utilizing online learning resources. These constraints not only affect the learning process in the classroom but also potentially hinder the mastery of skills that are highly needed in the workforce, which in turn can affect students' future career opportunities.

D. The Role of BIM in Improving Understanding of Steel Structure

Based on the results of thematic analysis, open coding and axial coding are obtained as follows.

Table 4.
Thematic Analysis Results of the Role of BIM in Improving Understanding of Steel Structures

No.	Open Coding	Axial Coding
1.	1. Interaction between steel structural elements (beams, columns, and joints) 2. Advantages in time efficiency and accuracy use of BIM in steel structure calculation and design 3. 3D visualization and simulation which helps in the understanding of steel structures 4. Clash detection and BIM features which reduces errors in calculation and design 5. Challenges in understanding and using BIM, which requires time and independent learning.	1. Efficiency and Accuracy in Design and Analysis of Steel Structures with BIM 2. Interactive Simulation and Visualization of Steel Structure with BIM 3. Speed and Accuracy in Steel Structure Design with BIM 4. Challenges in Learning and Using BIM.

Building Information Modeling (BIM) offers a clear visualization of the interactions between elements in steel structures, such as beams, columns, and connections, which greatly helps students in understanding the basic principles of steel structures. The clash detection feature in BIM also allows students to avoid design errors more effectively. In addition, BIM improves efficiency and accuracy in the design and analysis of steel structures by ensuring more precise calculations than manual methods through 2D-3D integration and collision detection features. The 3D visualization and simulation technology offered by BIM allows students to depict steel structures in a more complex and realistic manner, and facilitates real-time design updates between 2D and 3D drawings, ensuring that any design changes are accurately reflected. BIM also makes it easier for students to design steel structures faster and more precisely, reducing reliance on manual drawings and calculations, and speeding up the design process through automated calculations. Nonetheless, the challenges in understanding the various features of BIM require students to do more self-study and seek external sources to gain a deeper understanding of the use of this technology.

E. Perception on the Use of BIM in Civil Engineering Learning

Based on the results of thematic analysis, open coding and axial coding are obtained as follows Table 5.

The utilization of Building Information Modeling (BIM) in various courses other than Steel Structure in civil engineering has proven to be very effective in improving student understanding, including in Engineering Drawing, Concrete Structure, Plumbing, and Construction Management courses. BIM provides modern technological solutions that are highly relevant and needed in today's construction industry. In addition, BIM also plays an important role in preparing students for the world of work, especially in large projects that require skills in design, visualization, cost estimation, and volume calculation. This agrees with Building Engineering Education students who argue that: “Oh yes, it is very important, because again, in the industrial world it is now using BIM, so other courses must immediately use BIM, so that when you graduate, you already have skills in BIM, opening up wider job opportunities” (D, Interview 11/02/2025).

Table 5.
Perception on the Use BIM in Civil Engineering Learning

No.	Open Coding	Axial Coding
1.	1. Effectiveness of Using BIM in Learning 2. Courses that can be integrated with BIM 3. The Role of BIM in Preparing Students for the Construction Industry 4. Challenges in the Use of BIM 5. Role of BIM in Skill and Career Enhancement.	1. Use of BIM in Other Civil Engineering Courses 2. Civil Engineering Courses that Benefit from BIM 3. BIM as a Key Skill for the Construction Industry 4. Challenges in BIM Learning in Civil Engineering 5. BIM as a Skill for Career Opportunities in the Construction Industry 5

Mastery of BIM also provides a significant competitive advantage in the job market, as these skills are highly valued by large construction companies and open up extensive career opportunities. However, the implementation of BIM in civil engineering education faces challenges, such as the complexity of features that need to be well understood and the lack of introduction of BIM in the classroom. Therefore, more in-depth training, specialized BIM classes, as well as further integration of BIM in related courses, are needed. For BIM to be optimally utilized, civil engineering education needs to integrate this technology in various courses, provide hands-on practicum, and support the development of classes that are more applicable and relevant to industry needs.

F. Suggestion for Improved Use of BIM

Based on the results of thematic analysis, open coding and axial coding are obtained as follows.

Table 6.
Suggestion for Improved Use of BIM

No.	Open Coding	Axial Coding
1.	1. Improved BIM learning in Steel Structure 2. Development of BIM usage in the PTB study program 3. Preparation of students for the world of work 4. Suggestions for improving the use of BIM	1. Intensive BIM introduction and training 2. Integration of BIM in the course curriculum 3. Career preparation through mastery of BIM 4. Development of interactive learning with peer tutors.

To optimize Building Information Modeling (BIM) learning, students need an early introduction and intensive training to better master BIM features. Lecturers should also have adequate skills in teaching BIM, with a more interactive learning approach supported by hands-on guidance and peer tutors. In addition, the provision of adequate infrastructure, such as high-specification computers and the latest BIM software, is very important to support an effective learning process. The integration of BIM in more civil engineering courses will provide a broader understanding of its application in structural design and drafting, and prepare students to enter a construction industry that is increasingly reliant on this technology. Mastery of BIM also helps students develop professional skills that are much needed in the world of work, especially in large companies that prioritize BIM technology in their projects. To support the effective use of BIM, adequate learning facilities are essential, including hardware and software that are in line with the latest technological developments. One of the Building Engineering Education students

opined that “Maybe it should be upgraded again in terms of computer specs, lab specs, the BIM lab. Because yes, in using BIM, we must have a large computer spec, which is big. So there is no lag, no hang-ups” (J, Interview/12/02/2025). In addition, the development of collaboration with the construction industry will provide students with real experience and opportunities to interact with professionals in the field, expanding their opportunities to work on real projects and develop practical skills relevant to industry needs.

In addition, the results of this study calculated the coefficient of determination and obtained the following results:

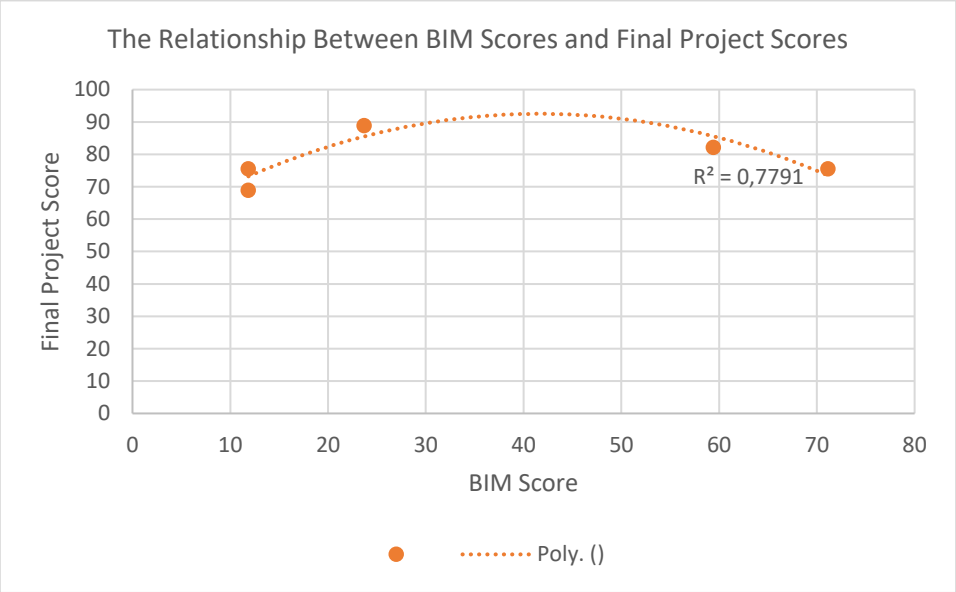

Figure 6. The Relationship Between BIM Scores and Final Project Scores

Based on the figure above, it is known that the coefficient of determination or Adjusted R Square is 0.7791, which shows that the Steel Structure Learning outcomes can be explained by 77% of the BIM Skills test scores. This shows that the value of the BIM skills test affects the learning outcomes of the Steel Structure.

2. Discussion

This research aims to find out the students' experience in using BIM to understand the concept of Steel Structure. In addition, this study also wants to know the extent of mastery of BIM skills and how students' learning outcomes are during the learning of steel structure II. This analysis uses Microsoft Excel software and SPSS (Statistical Program for Social Science) version 25. The test questions used in this study were validated by experts. The questions used need to be tested for content validity by experts to test the feasibility of the research instrument, in this case, a test in the form of a description. This validity test was carried out by two experts, namely Mr. A P, S.T., M.T. is a lecturer in the structure of the Applied Bachelor of Building Construction Engineering Technology study program, and Mrs. N A, S.Pd., M.Sc. is a structural consultant at PT WitteveenBoss Indonesia. According to Lawsche's content coefficient of 1 indicates that the content validity falls into the high category, so that this assessment instrument can be developed and disseminated, provided that indicators are added to the sheet to be given to students.

Based on the results of the research, it is known that the mastery of BIM skills of students of the Building Engineering Education study program at the State University of Jakarta is still very low. The results of the BIM test on 3 types of BIM platforms, namely 2D drawings (Plan), 3D Models in Revit, and ETABS, show very low scores; most students cannot carry out the test properly, so they get a score of 0. This shows that almost all students have an inability to use BIM. This can be due to the absence of adequate BIM training for students to follow. Research (Sunardi, 2024) showed that most vocational teachers scored low on the BIM pretest, but after the BIM training, the teachers' scores increased. This shows that BIM training is needed in building engineering education.

Furthermore, on the variable of student learning outcomes in the Steel Structure II course at the State University of Jakarta, it is known that on average most student learning outcomes fall into the moderate category, namely 22 students or 74%, then into the high category as many as 7 students or 23%, and only 1 student or 3% falls into the low category. These results indicate that the learning outcomes of steel structure II have a fairly good average in the class.

The application of BIM in learning Steel Structure II in the UNJ Building Engineering Education Study Program has a significant impact in helping students understand the concept of steel structure, especially through 3D visualization. However, the main obstacle faced by students is the low mastery of BIM software, due to limited training and facilities available. This is in accordance with previous research, which shows that a lack of experience and facilities supports the mastery of BIM among students (Setiawan, 2022). BIM has emerged as a technology that significantly changes the field of civil engineering, especially in the learning and application of steel structures. The integration of BIM in the educational framework provides many advantages, which can improve students' understanding and practical skills in steel structure design and construction.

One of the main advantages of using BIM in steel structure learning is its ability to provide detailed visualization and simulation. BIM allows students to create and manipulate 3D models of steel structures, which helps them understand complex geometry and spatial relationships. This visual representation is essential for understanding the intricate details in steel construction, such as connections, load paths, and material properties (Avendaño et al., 2022; Chen et al., 2020). In addition, the interactive nature of BIM software provides a hands-on learning experience, allowing students to experiment with design modifications and immediately see their impact on the overall structure (Ma & Tao, 2023; Lee et al., 2022).

BIM also enhances collaboration between disciplines involved in steel structure projects. By using a shared BIM platform, students can learn to communicate effectively with architects, engineers and contractors, which is essential for project success (Chen et al., 2020; Wang & Lu, 2024). This collaborative environment reflects real-world practices, preparing students for future professional roles that require teamwork and interdisciplinary communication (Soh et al., 2021). In addition, the integration of BIM with project-based learning (PBL) methodologies allows students to engage in practical projects that reflect industry standards, which enhances their problem-solving and critical thinking skills (Ma & Tao, 2023).

In addition to improving visualization and collaboration, BIM contributes significantly to the efficiency and accuracy of the design process. The software automates various tasks, such as generating 2D drawings from 3D models and performing structural analysis, which reduces

the likelihood of errors and increases productivity (Avendaño et al., 2022; Sun, 2024). Students can utilize these automation processes to streamline their design workflows, which gives them insight into best practices in the industry (Xia, 2020). In addition, BIM's ability to integrate data from multiple sources enables a comprehensive assessment of structural performance, sustainability, and cost-effectiveness, which are important considerations in modern steel construction (Wang et al., 2024; Yu et al., 2021).

Another important aspect of BIM in the context of steel structures is its role in sustainability and environmental impact assessment. Using BIM tools, students can analyze material life cycles, assess energy consumption, and explore recycling options for steel components (Llatas et al., 2022; May, 2021). This exposure to sustainable practices equips future engineers with the knowledge to make environmentally friendly decisions in their projects, in line with global efforts towards sustainable development (Zou et al., 2024).

Therefore, to improve students' understanding and skills, there is a need for improved facilities, more intensive training, and the use of more interactive project-based learning methods. Thus, students will be better prepared to face industry challenges that increasingly rely on the use of BIM in design and construction.

CONCLUSION

This research shows that the use of BIM in learning Steel Structure is very useful to deepen students' understanding of the concept of Steel Structure. However, to increase the effectiveness of the use of BIM, several improvements are needed, including earlier introduction of BIM, intensive training, improvement of facilities that support BIM, and integration of BIM in other courses. Collaboration with the construction industry is also very important to provide real experience that will strengthen students' readiness to enter the workforce. BIM is widely used in major assignments that require students to apply steel structure concepts using applications such as Revit and ETABS. The use of BIM outside of major assignments, in daily learning, is still limited. Most students were initially unfamiliar with BIM, and the application of BIM in the major project gave them a deeper understanding of the technology. Students who had no prior experience with BIM had difficulty understanding how BIM applications worked, especially in Revit operations. The absence of formal training before the use of BIM was a major obstacle. To overcome these difficulties, students relied heavily on online tutorials and group discussions, which proved to be helpful in overcoming technical barriers in using BIM.

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