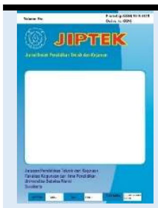

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Analysis of Factors Hindering DPIB Students' Adaptation to the Implementation of Building Information Modeling at SMKN 6 Bandung

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ABSTRACT

Building Information Modeling (BIM) implementation in vocational education in Indonesia, especially in vocational schools, faces significant challenges such as technology gaps, technical complexity of BIM systems, and limited supporting facilities. This study aims to analyze the inhibiting factors of BIM adaptation in students majoring in Building Information Modeling Design (DPIB) at SMKN 6 Bandung using a descriptive quantitative method. Evaluations were conducted on facilities, student readiness, curriculum, teacher learning methods, and external support. The results of this study indicate that (1) facilities are the main obstacle due to limited infrastructure (hardware/software) and practice space; (2) student readiness is disrupted by low digital literacy and dependence on teachers; (3) the curriculum is not yet responsive to industry needs, (4) teacher learning methods use a passive approach that contradicts the principles of constructivism; and (5) external support is incidental. Thus, BIM integration requires a holistic approach, namely improving facilities, project-based curriculum, teacher training, and strategic partnerships. These solutions are important to achieve effective BIM integration to bridge the gap between graduate competencies and industry needs.

***Keywords**:Building Information Modeling (BIM), Vocational Education, Implementation Challenges, Student Adaptation, Construction Industry*

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INTRODUCTION

The implementation of Building Information Modeling (BIM) technology in the construction sector has significantly transformed the processes of planning, design, and project management. BIM manages project data through building modeling and presents information to stakeholders to support decision-making and integrated project management (Rizky Hutama & Sekarsari, 2019). Although it has been proven to improve efficiency in the construction industry and is widely adopted in developed countries, the implementation of Building Information Modeling (BIM) in Indonesia—particularly in the vocational education sector—remains far from adequate, creating a gap between industry needs and the readiness of a skilled workforce. This situation is evident because, although BIM has been widely adopted in developed countries such as Singapore and the United States, its implementation in Indonesia particularly within the vocational education sector—remains lagging (Utomo & Rohman, 2019). Data supports this, showing that only 60% of Indonesian construction companies have partially adopted BIM, hindered by a lack of experts, resistance to change, and high costs (Hasanah Putri & Sri Handoyo, 2023).

As educational institutions that produce skilled workers, vocational high schools (SMK) must continue to adapt to advances in industrial technology, including BIM, and equip students with skills that meet the demands of the modern construction industry. However, the implementation of BIM in the learning process is still not optimal. Research by Sucipto et al. (2024) reveals that the majority of educators at vocational high schools have a limited understanding of BIM, making it difficult for them to teach it effectively. Therefore, competency enhancement through ongoing training is necessary, as the low level of BIM implementation in vocational high schools is primarily due to a lack of teacher readiness.

This study integrates two theories: the Theory of Innovation Diffusion (Rogers, 1962) and Constructivism (Piaget, 1972) to promote the use of Building Information Modeling (BIM) in vocational high schools. The Theory of Diffusion of Innovations provides insights into the factors that accelerate technology adoption, including curriculum alignment with BIM, highlighting the advantages of BIM, ease of trial use, visibility of results, and the importance of collaboration among stakeholders. Meanwhile, Constructivist Theory emphasizes active learning through direct experience and practice. The integration of these two theories is crucial because the adoption of BIM depends not only on the availability of technology but also on students' deep understanding and active participation. This integration yields five key components: an industry-standard curriculum, adequate practical facilities, competent teachers, intrinsic student motivation, and systemic support from industry and the government.

These five key components are implemented through strategic measures. The curriculum is aligned with BIM Level 2 industry standards and enriched with real-world project-based learning. Practical facilities, such as BIM labs, are equipped with the latest software for experimentation, result analysis, and student collaboration. Teachers' competencies are enhanced both technically and pedagogically to facilitate active learning. Student motivation is stimulated through explanations of the career benefits of BIM and engaging problem-based learning methods. External support from industry and government is realized through BIM standard policies, internship programs, and real-world case studies. With this integrative strategy, the research objective is to achieve effective BIM adoption and produce graduates who are adaptable through meaningful and contextual learning experiences.

Several previous studies on barriers to Building Information Modeling (BIM), such as those conducted by Alrizqi and Fazri (2023), Irvansyah, N. (2024), Hasanah Putri and Sri

Handoyo (2023), and Subroto et al. (2023), highlight the main barriers to the implementation of Building Information Modeling (BIM) technology in vocational high schools (SMK), including limited access to licensed software and high infrastructure costs, compounded by a lack of training, teachers' lack of readiness, and minimal policy and funding support. Unlike previous studies, which generally focus on BIM in construction projects or higher education institutions, this research will describe the implementation of BIM in a vocational high school setting. This study was conducted at SMKN 6 Bandung, the largest construction vocational school in the city of Bandung (Ministry of Education and Culture, 2024). The selection of this large school was based on the complexity of its facilities, curriculum, and resources, which can reflect systemic barriers to BIM implementation in vocational education (Pantiga & Soekiman, 2021).

This study focuses on 12th-grade students majoring in Building Design, Modeling, and Information (DPIB) at SMKN 6 Bandung, class of 2024/2025, who are currently in a critical phase leading up to their transition into the workforce or higher education. During this phase, proficiency in Building Information Modeling (BIM) is a critical prerequisite for aligning graduates' competencies with the demands of the modern, digitally-based construction industry (Mieslenna & Wibowo, 2019). By analyzing the challenges faced by students and educators at SMKN 6 Bandung, this study aims to provide new insights and practical recommendations for schools, the government, and the industry to strengthen the implementation of BIM in vocational high schools (Heryanto et al., 2020).

This study aims to analyze the factors hindering students' adaptation to BIM, including knowledge, technical skills, and attitudes toward technology. In addition, this study also evaluates teachers' readiness and competence in teaching BIM, including the availability of training and barriers to practical learning, in order to identify the crucial role of educators in curriculum implementation. In the next phase, this study seeks to present comprehensive strategic solutions to bridge the competency gap between vocational high school graduates and the dynamic demands of the construction industry. A deep understanding of these strategic solutions is crucial for ensuring the relevance of vocational high school graduates (Alverinaldo & Nugroho, 2024).

RESEARCH METHODOLOGY

This study implemented a descriptive quantitative approach to identify factors hindering BIM adaptation among DPIB students at SMKN 6 Bandung. The research subjects consisted of 60 students from a total population of 150 twelfth-grade students majoring in DPIB during the 2024 - 2025 academic year, while the research focus was on identifying factors hindering the implementation of BIM. The research instrument, a validated Likert-scale questionnaire, was distributed to students to measure the barriers to their BIM adaptation.

The data analysis techniques used in this study included the processing of questionnaire data from the book, which was analyzed descriptively using Microsoft Excel. Based on

Sugiyono's (2017) guidelines, data processing in this study was conducted by calculating the percentage of each identified factor hindering BIM adaptation: (1) curriculum, (2) facilities, (3) teacher competence, (4) student motivation, and (5) industry/government support. These five aspects were used to prioritize the barriers as a basis for developing strategies to improve BIM adoption in the learning of students majoring in Building Modeling and Information Design (DPIB).

RESEARCH FINDINGS AND DISCUSSION

Data were collected through a Google Form distributed to 12th-grade students in the Building Modeling and Information Design (DPIB) program at SMKN 6 Bandung. Data regarding barriers to the implementation of Building Information Modeling (BIM) were collected using a closed-ended questionnaire consisting of 20 questions. The research instrument was designed based on the three main dimensions of the diffusion of innovation theory, namely: (1) facilities, (2) curriculum, and (3) student readiness. Additionally, the instrument also drew upon two dimensions of constructivist theory, namely (1) student readiness and (2) teacher competence. It should be emphasized that the focus of this study is on inhibiting factors; therefore, the analyzed data only includes negative responses (percentages below the ideal criteria) from the total data collected.

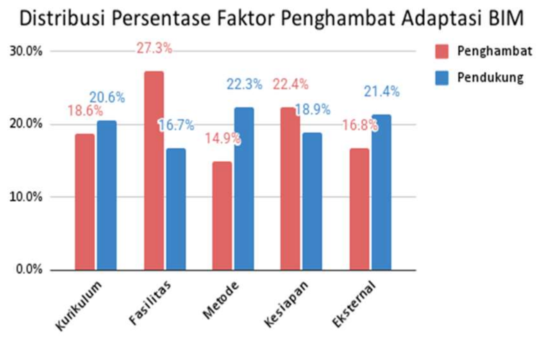

Figure 1. Percentage Distribution of Factors Hindering BIM Adoption

Based on the above findings, facilities emerged as the most dominant barrier, marked by the highest number of negative responses regarding limitations in supporting infrastructure and resources, such as hardware and software that are crucial for BIM implementation. Conversely, teaching methods were the strongest aspect, receiving the highest number of positive responses, indicating the effectiveness of teachers' instructional strategies. Furthermore, student readiness requires attention; students' difficulty in understanding basic BIM concepts highlights the need to strengthen prerequisite material and provide hands-on training. Similarly, the curriculum needs to be evaluated and adapted to keep pace with advancements in BIM technology and industry needs. Finally, although support from industry and the government has a positive impact, there are inconsistencies in its implementation.

The prioritization of these identified barriers underscores the need to understand that the five aspects examined are closely interrelated and form an integrated system in the BIM integration process at vocational high schools. Based on the order of the barriers' significance, the discussion of these key factors is expected to serve as the foundation for designing concrete steps to enhance the use of BIM at SMKN 6 Bandung.

a. Facilities

Barriers related to facilities in BIM adoption—with 27.3% of negative responses—indicate that the lack of adequate infrastructure is a major obstacle to learning. Technical issues such as lag, errors, and crashes not only disrupt the learning process but also diminish students' interest in exploring BIM more deeply. Limited practice space and unstable internet connections further restrict students' opportunities for independent practice, thereby hindering their mastery of BIM technology. These conditions indicate that without improvements to facilities, efforts to integrate BIM in vocational schools will struggle to achieve optimal results, as poor infrastructure creates a learning environment that does not support innovation.

These findings align with the Theory of Innovation Diffusion, particularly regarding the dimensions of complexity and trial capability. Limitations in hardware and software that meet BIM specifications increase users' perception of the technology's complexity, as technical obstacles such as lag or crashes make BIM appear difficult to operate. Additionally, limited access to adequate devices restricts opportunities for trial use, which is a key factor in the innovation adoption process. A study by Utomo & Rohman (2019) reinforces this argument by showing that inadequate facilities reduce students' ability to experiment and understand the benefits of BIM firsthand.

From the perspective of Constructivism, limited facilities hinder experience-based learning, which is essential for building knowledge. This theory emphasizes the importance of active interaction with learning tools and the environment to construct understanding. However, without access to a fully equipped BIM lab or a stable internet connection, students lose the opportunity to engage in hands-on activities that support conceptual understanding. This aligns with the findings of Rizky Hutama & Sekarsari (2019), who state that a lack of practical resources causes BIM learning to tend toward being theoretical and less practical, thereby contradicting the "learning by doing" principle in constructivism.

b. Student Readiness

The level of student readiness, as indicated by 22.4% of negative responses, suggests an overreliance on teacher instruction and a lack of initiative in exploring BIM features. This reflects a lack of self-confidence and independent learning skills, which could potentially hinder mastery of complex technologies such as BIM. These findings suggest that passive learning patterns not only reduce the effectiveness of practice but also limit students' creativity in solving technical problems. Therefore, an approach that fosters independence through the empowerment of digital literacy and systematic mentoring is needed.

These findings align with Constructivist Theory, which emphasizes the role of mentor support and active interaction in knowledge construction. Students' tendency to wait for teacher instructions indicates a lack of the zone of proximal development, where students should be able to develop new skills with gradual guidance. A study by Susanti et al. (2023) reinforces this argument by showing that mentor guidance and the use of online platforms can serve as effective scaffolding to enhance students' active engagement. Without these interventions, students remain trapped in passive learning patterns that run counter to the principles of experience-based learning.

Furthermore, students' low readiness is also linked to weak digital literacy, as explained by Susanti et al. (2023). The theory outlined states that mastery of digital tools and access to self-directed learning resources are prerequisites for building technical competencies. In the context of BIM, students' inability to explore software features independently indicates a digital literacy gap, particularly regarding navigation tools, technical problem-solving, and the use of online resources. The digital portfolio system proposed in this study aligns with this theory, as the portfolio not only documents learning outcomes but also compels students to independently organize and reflect on the learning process—key skills in digital literacy.

c. Curriculum

The 18.6% negative response regarding the curriculum reflects a mismatch between the course material and the dynamics of the modern construction industry. Students tend not to see the concrete benefits of BIM because the curriculum remains focused on basic theory without integrating real-world cases or the latest technological developments. This situation indicates that this lag not only limits students' technical competencies but also creates the perception that BIM is an "irrelevant" or "difficult-to-apply" technology. The fact that only 60% of construction companies in Indonesia implement BIM partially (Hasanah Putri & Sri Handoyo, 2023) further underscores the urgency of adjusting the curriculum so that graduates can compete in the digital age.

These findings align with the Theory of Innovation Diffusion, particularly regarding the dimensions of compatibility and observability. First, a curriculum that is not aligned with industry needs leads to BIM being perceived as incompatible with real-world work contexts, thereby reducing the motivation to adopt it. Second, the lack of examples of BIM applications in course materials (such as case studies on clash detection or design optimization) hinders students' ability to observe the tangible benefits of this technology. Rogers (2003) states that innovations whose benefits are not clearly visible will face resistance during the adoption process. This is exacerbated by the findings of Hasanah Putri & Sri Handoyo (2023), which indicate low BIM adoption in the industry; consequently, a non-adaptive curriculum further reinforces these negative perceptions.

d. Teacher Instruction

The finding of a 14.9% negative response to teachers' instructional methods indicates a gap between conventional teaching approaches and the characteristics of BIM, which require technical and collaborative engagement. According to the findings, the predominance of lectures and passive demonstrations has created a one-way learning environment, in which students are merely recipients of information without the opportunity to actively explore BIM features. This not only reduces student interest but also hinders the development of problem-solving and collaboration skills—two core competencies in BIM mastery. If this pattern persists, students risk understanding BIM concepts only theoretically without being able to apply them in real-world project scenarios. Thus, to bridge the gap between theory and practice, this study suggests that adopting more interactive teaching methods—such as project-based learning or collaborative simulations—is a crucial step.

The results of this study contradict the principles of Piaget's (1954) constructivist theory, which asserts that effective learning occurs when students actively construct their knowledge through real-world experiences and social engagement. BIM, as a technology-based and collaborative tool, should be taught through an approach that facilitates scaffolding and the zone of proximal development (ZPD), in which the teacher acts as a facilitator rather than a one-way conveyor of information. The dominant lecture method, however, overlooks these social-constructivist aspects, leaving students without the opportunity to test, experiment with, or discuss the application of BIM in real-world contexts. Constructivist theory also emphasizes that technical learning such as BIM requires an environment that encourages inquiry and reflection—factors that are absent in the observed teaching methods.

The results of this study contrast with the findings of Hartono et al. (2021), who stated that passive demonstrations remain effective for basic BIM instruction. This discrepancy can be explained by the difference in context: Hartono et al. studied beginner-level students, whereas this study focused on students who had already reached the advanced application stage. The findings regarding barriers to the development of collaboration skills reinforce the argument by Purnomo et al. (2024), who suggest integrating collaborative problem-solving into the BIM curriculum. Consequently, teaching approaches need to be tailored to the complexity of the material and the learning phase, while continuing to prioritize constructivist principles during the application stage.

e. External Support from Industry or Government

Research findings indicate that external support from industry and government for education-vocational collaboration has been met with a positive response, although 16.8% of respondents expressed doubts about the program's sustainability. Based on the findings, these doubts reflect a disparity between institutions' formal commitments and practical implementation on the ground. Although joint internship and training programs have been initiated, some students have not yet felt their direct impact because industry involvement remains incidental and is not integrated into the long-term curriculum. This suggests the need for an evaluation mechanism based on student feedback to ensure that collaborative programs are not merely symbolic but truly address competency needs in the workplace, particularly in the application of technologies such as BIM.

The results of this study are partly consistent with Rogers' (2003) Theory of the Diffusion of Innovations, which states that the adoption of innovations (such as school-industry collaboration) depends on the perceived benefits, compatibility, and complexity. The positive responses from the majority of participants indicate that this collaboration is considered compatible with vocational learning needs, particularly in the context of BIM adoption. However, the doubts expressed by 16.8% of participants regarding the program's sustainability contradict Rogers' assumption about the role of user-driven reinvention and adaptation of innovations in ensuring sustainability. In this context, reinvention failed to occur due to the lack of student involvement in program design, resulting in a collaboration that tended to be top-down. Rogers' theory also does not fully account for the role of the government as a regulator that can accelerate the diffusion of innovation through incentive policies a crucial factor identified in this study.

The research findings reinforce the argument put forth by Purnomo et al. (2024) that systematic partnerships between schools and industry are key to reducing the skills gap. However, these results indicate a contextual difference from previous research settings, which had more lenient government policies, thereby allowing industry to play a more dominant role. Respondents' doubts regarding the program's sustainability also reflect common challenges in education-industry collaboration, particularly regarding the consistency of long-term budget allocations. Consequently, the three-way synergy (schools-industry-government) needs to be strengthened through a legal framework that defines each party's responsibilities, such as multisectoral contracts or tiered funding schemes.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Based on the research findings, the adoption of Building Information Modeling (BIM) among students at SMKN 6 Bandung still faces systemic barriers, with facilities being the dominant factor. Infrastructure limitations—such as inadequate hardware, limited licensed software, and substandard practice spaces—create a perception of BIM's complexity among students. Student readiness is also a critical issue, characterized by a reliance on teacher instruction and low digital literacy for independent exploration. These findings contradict the common assumption that the main obstacle lies in teacher competence; rather, they indicate that external factors such as facilities and student readiness are often overlooked.

The curriculum is deemed unresponsive to industry dynamics, while industry and government support remains sporadic and unsustainable. This indicates that the vocational education ecosystem is unprepared to face digital transformation. Therefore, holistic solutions including facility improvements, project-based curricula, teacher training, and strategic partnerships are necessary to bridge the competency gap. Thus, these findings underscore that the integration of BIM in vocational high schools must be viewed as a process of cultural transformation, not merely a curricular or technical change.

RECOMMENDATIONS

The results of this study still have limitations in analyzing long-term impacts and the various challenges that may arise. In light of this, further steps are needed to strengthen the findings. First, a longitudinal study with a broader scope, such as one involving all DPIB vocational high schools in Bandung, is essential to evaluate the sustainability of the positive impact of improved facilities and curriculum revisions on students' BIM competencies. Second, the assessment of BIM competencies needs to be optimized through tests or practical simulations to enhance the accessibility and objectivity of measuring students' technical skills, particularly in vocational high schools with limited facilities. Third, the application of a mixed-methods approach in future research will provide a deeper understanding of the psychological and sociocultural dimensions that influence both students and teachers, thereby contributing maximally to the development of an adaptive and sustainable BIM learning ecosystem.

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