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**Lilik Hariyanto, Indah Wahyuni & Galeh Nur Indriatno Putra Pratama**

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Research paper

## Implementation and Design of Building Information Modeling (BIM) Oriented Learning in the Building Information and Modeling Design Program (DPIB)

Lilik Hariyanto<sup>1</sup>, Indah Wahyuni<sup>\*2</sup>, Galeh Nur Indriatno Putra Pratama<sup>3</sup>

<sup>1</sup> Universitas Negeri Yogyakarta, Department of Civil Engineering and Planning Education, Faculty of Engineering, Indonesia

<sup>\*</sup>Corresponding Author: [indahwahyuni@uny.ac.id](mailto:indahwahyuni@uny.ac.id)

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### ABSTRACT

**Background:** BIM is the operational standard for the modern construction industry. This study aims to describe the implementation of Building Information Modeling (BIM) learning in vocational high schools that have a Building Modeling and Information Design program, as well as to formulate a structured Learning Objective Flow in accordance with the principles of the Merdeka Curriculum and the demands of the construction industry.

**Methods:** This study uses a descriptive quantitative approach involving teachers of BIM-related subjects and students in grades X, XI, and XII from SMKN 2 Depok, SMKN 2 Yogyakarta, SMKN 3 Yogyakarta, and SMKN 1 Sedayu. Data were collected through closed-ended questionnaires based on a Likert scale and open-ended questionnaires, then analysed using descriptive statistics to determine trends in each aspect of the study.

**Results:** The results show that the implementation of BIM learning still faces various obstacles, especially in terms of human resources, availability of facilities and infrastructure, curriculum integration, teaching methods, and managerial support. The uneven competence of teachers and the limitations of licensed hardware and software are the main obstacles.

**Conclusion:** This study succeeded in formulating an adaptive, systematic, and contextual learning objective Flow. This flow includes objectives, achievement indicators, learning activities, and assessments that are arranged in stages, starting from mastering basic software skills to developing collaborative projects based on Building Information Modeling (BIM). The findings of this study are expected to provide practical contributions in strengthening the readiness of vocational high schools to implement Building Information Modeling (BIM)-based learning in a focused and sustainable manner.

## INTRODUCTION

Vocational education in various countries is currently at the forefront in responding to the challenges of the Fourth Industrial Revolution. Globally, the Vocational Education and Training (VET) system is evolving to strengthen the connection between school learning and the demands of the industrial world. Iliescu et al. (2025) emphasize that VET plays a crucial role in preparing a globally competitive workforce with skills. Countries such as Germany and Switzerland have long developed a dual system, while the United States has adopted a school-based model. International initiatives such as PISA-VET also encourage the harmonization of vocational competencies, including in the digital construction sector.

In line with these developments, the global construction industry is experiencing accelerated digitalization through the adoption of Building Information Modeling (BIM). BIM is a 3D digital model-based approach that enables the integration of building design, construction, and operational information into a single integrated platform (Famdale & Widyadana, 2023). The use of BIM eliminates complicated and time-consuming documentation. The BIM database facilitates the merging of information into the project and improves the coordination of document management (Lot Tanko & Mbugua, 2021). In its implementation, the level of training and qualification of personnel in the field of BIM is an important factor (Mysak & Mysak, 2024). BIM as a technology and method continues to evolve, making it crucial that the BIM knowledge and skills taught in BIM courses are aligned with industry needs (Guo et al., 2023).

In many developed countries, BIM has become a standard in vocational education curricula in the field of construction. Vietnam, for example, has developed an institution-industry collaboration model to ensure that BIM training in TVET is truly in line with job market competencies (Hoai Le et al., 2022). The implementation of BIM has been proven to improve the employability of graduates, as shown by Nguyen & Nguyen (2020) at Ho Chi Minh City Construction College, where 88% of graduates were immediately absorbed by the industry and had higher incomes than CAD-based graduates. In Malaysia's TVET program, BIM integration will align the program with global industry standards and equip future workers with the appropriate skills (Ismail et al., 2025). Research from Aeng & Noh@Seth (2025) shows that making BIM a compulsory subject in vocational education is an appropriate and positive step, especially since Malaysia is striving to achieve its Construction 4.0 goals. Rasmiet et al. (2025) emphasize the importance of structured training programs and collaboration with industry partners in TVET pedagogy to ensure that BIM education supports both technical competence and creative learning. Enhancing the quality of BIM instruction is expected to increase graduates' employability and adaptability in response to the dynamic demands of the construction industry.

A similar experience can be seen in China, which has historically built the world's largest vocational education system and continues to strengthen the integration of digital technologies, including BIM, into its learning (Yang & Zheng, 2025). Previous research in the field of education has proposed various innovative approaches in the design and development of BIM curricula to improve their suitability to the needs of a dynamic industry and technological developments (Ahankoob et al., 2025). In general, various studies confirm that the integration of BIM in vocational education is not merely about mastering software, but also includes the development of collaborative learning, project-based problem solving, and communication and visualization skills.

In the context of architectural education, BIM plays an important role in developing design and interdisciplinary collaboration skills, as well as providing access to more comprehensive simulations and visualizations (Çakir & Uzun, 2020). There is a need to mobilize the entire education ecosystem to achieve satisfactory progress towards effective innovation in BIM-based contemporary design teaching (Ledda et al., 2025). These findings are in line with the need for a concentration on Building Modeling and Information Design at Vocational High Schools in Indonesia, which are now required to implement project-based, collaborative learning models that meet industry standards.

BIM education emphasizes the collaborative use of systems and tools through industry involvement in curriculum development to provide students with practical experience and an understanding of industry expectations (Hoai Le et al., 2022). BIM for Construction Education (BfCE) refers to academic efforts to educate Architecture, Engineering, and Construction (AEC) students in the use of BIM tools and the application of BIM to enhance learning (Sucipto et al., 2024). The integration of theoretical learning and practical training encourages innovation in practice and reinforces experience-based learning. The development of integrated BIM practice platforms enables the simulation of the entire project life cycle, while BIM's capabilities in visualization, simulation, and digitization support a more comprehensive understanding of applied learning processes (Zhang, 2023). A progressively structured BIM learning approach, starting from basic concepts to advanced applications throughout the curriculum, is considered most beneficial (Kim et al., 2025). Malaysian TVET institutions that implement BIM through curriculum design, strengthen collaboration with industry professionals, and provide adequate education and training for educators (Ismail & Mustafa Kamal, 2023). Rahman et al. (2025) explain that effective BIM implementation requires proper planning in line with industry needs, active learning approaches such as project-based learning, and assessments that measure both technical knowledge and practical performance to meet the expectations of the AEC industry.

Correa et al. (2025) added that as BIM becomes more widely used in AEC practices, higher education institutions are required to adjust their curricula to keep pace with the ever-changing needs of the industry. Overall, BIM learning can be understood as a structured educational process that integrates industry-oriented curricula, progressive learning stages, and the combination of theoretical and practical approaches to develop technical competence and professional readiness in the AEC field.

In Indonesia, the urgency of BIM implementation is increasing in line with DUDIKA's demands, which have begun to make BIM the operational standard for the modern construction industry (Kamdhi & Jaedun, 2022; Hatmoko et al., 2019). However, the national adoption rate of BIM is still low, at only 35% in 2019 (Utomo, 2019). This low utilization is influenced by limited human resources and a lack of competent teaching staff in BIM (Ramadhan et al., 2022; Naufalia, 2023). To address this gap, the government has included BIM as one of the learning outcomes in the DPIB subject in the Merdeka Curriculum (Kemdikbudristek, 2022).

Research results in various vocational schools show that BIM learning can improve technical competence, learn motivation, and understanding of construction concepts through 3D models (Aryanti et al., 2020; Sunardi, 2024). However, implementation challenges are also evident in the form of limited equipment, a shortage of BIM-certified teachers, and suboptimal school management (Nugroho & Hariyanto, 2024). These conditions underscore the need for a more systematic and adaptive learning design.

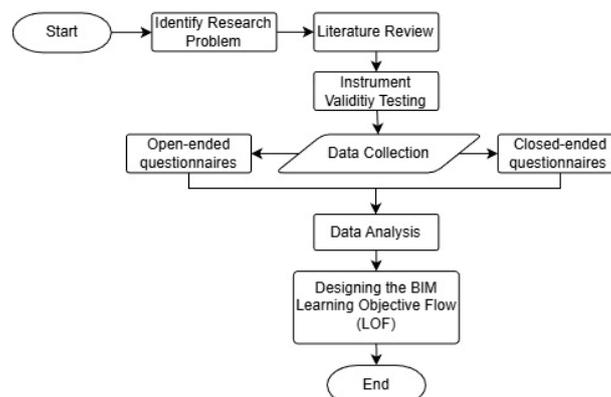
In line with the principles of the Merdeka Curriculum, one of the strategic approaches needed is the development of a structured BIM Learning Objective Flow (LOF), starting from mastering basic skills to completing BIM-based collaborative projects. According to Kemdikbudristek (2024) and Rini et al. (2023), the LOF must be structured in a linear, logical, and contextual manner, considering the characteristics of students and the availability of facilities and infrastructure.

Based on these findings, this research is important because it not only maps the implementation of BIM in vocational schools but also offers concrete solutions in the form of an applicable, adaptive LOF for BIM learning that meets the needs of today's construction industry. Thus, this research is expected to contribute to strengthening the readiness of vocational schools to implement BIM learning in a systematic, sustainable manner that is relevant to modern industry standards.

This study aims to describe the implementation of Building Information Modeling (BIM) learning in vocational schools, particularly in the Building Modeling and Information Design program, as a response to the challenges of the construction industry in the era of Industrial Revolution 4.0. This study also aims to formulate a structured, adaptive, and applicable Learning Objective Flow (LOF) in accordance with the principles of the Merdeka Curriculum and the needs of the construction industry. Through this approach, the study is expected to contribute to the development of a systematic and sustainable BIM-based learning framework to improve students' technical competence, collaborative skills, and work readiness in accordance with industry standards.

## METHODS

This study uses a descriptive quantitative approach that aims to describe the factual conditions of Building Information Modeling (BIM) implementation in the Building Modeling and Information Design (DPIB) concentration at four vocational schools. Quantitative descriptive methods are research methods used to describe and summarize data statistically in order to understand the characteristics and patterns of the research sample. The research flowchart can be seen in Figure 1.



**Figure 1.** Research Flowchart

The research population involved BIM subject teachers and students in grades X, XI, and XII in the DPIB program at vocational schools in the Yogyakarta area, including SMKN 2 Depok, SMKN 2 Yogyakarta, SMKN 3 Yogyakarta, and SMKN 1 Sedayu. The research sample was

determined using proportionate stratified random sampling for students and purposive sampling for teachers, so that representative data were obtained from each school.

Instrument validity testing can be conducted through several approaches, such as content validity, specifically by lecturers from the Department of Civil Engineering Education and Planning at Yogyakarta State University who have expertise in learning implementation, and construct validity, which aims to determine the extent to which the instruments used can measure data related to the level of implementation of Building Information Modeling (BIM) learning and to assess whether each item in the questionnaire that has been compiled meets the validity criteria.

Data collection was conducted using two types of questionnaires, namely closed questionnaires and open questionnaires. Closed questionnaires used a five-point Likert scale and were given to teachers and students to obtain quantitative data on their views on various aspects of BIM implementation. The aspects measured included human resources, facilities and infrastructure, curriculum, learning materials, learning methods, learning evaluation. The open-ended questionnaire was only given to teachers to obtain more in-depth information about the challenges and strategies in implementing BIM learning.

The data obtained was analysed descriptively using simple statistical techniques to obtain the mean, median, mode, and standard deviation of each aspect studied. After that, an aspect trend analysis was conducted to provide clarity in grouping the measurement results of the research aspects. These trends were determined based on the scores obtained, then classified into the following five trend categories.

**Table 1.**  
Aspect Trend Categories

No	Interval	Category
1	$M_i + 1.8 SD_i < X$	Very Good
2	$M_i + 0.6 SD_i < X \leq M_i + 1.8 SD_i$	Good
3	$M_i - 0.6 SD_i < X \leq M_i + 0.6 SD_i$	Fair
4	$M_i - 1.8 SD_i < X \leq M_i - 0.6 SD_i$	Poor
5	$X \leq M_i - 1.8 SD_i$	Very Poor

## RESULTS AND DISCUSSION

The research population involved BIM subject teachers and students in grades X, XI, and XII in the DPIB program at vocational high schools in the Yogyakarta area, including SMKN 2 Depok, SMKN 2 Yogyakarta, SMKN 3 Yogyakarta, and SMKN 1 Sedayu. The research sample was determined using proportionate stratified random sampling with a total of 452 students and purposive sampling of 16 teachers, thus obtaining representative data from each school.

### A. Implementation variables for BIM learning

The variables in this study are the implementation of BIM learning in building modeling design elements. The implementation of BIM learning in this context is measured using several sub-variables, including: (1) human resources, namely teacher competence and student readiness to participate in learning; (2) supporting facilities and infrastructure, such as the BIM hardware and software used; (3) the curriculum and its suitability to industry needs; (4) the learning materials used in teaching and learning activities; (5) learning methods/approaches applied by teachers in BIM learning; and (6) learning evaluation.

**Table 2.**

Variable Instruments for BIM Learning Implementation

No	Sub-Variable	Indicator	School	Category
1	Human Resources	1. Availability of teachers with BIM competencies	Vocational High School 2 Depok	Fair
		2. Teachers skilled in implementing effective BIM learning strategies	Vocational High School 1 Sedayu	Very Good
			Vocational High School 2 Yogyakarta	Fair
			Vocational High School 3 Yogyakarta	Fair
		1. Availability of tools that support the BIM learning process	Vocational High School 2 Depok	Fair
			Vocational High School 1 Sedayu	Very Poor
2	Facilities and Infrastructure	2. Availability of teaching materials that support the BIM learning process	Vocational High School 2 Yogyakarta	Good
			Vocational High School 3 Yogyakarta	Good
		1. Relevance of the BIM learning curriculum to the business and industrial world	Vocational High School 2 Depok	Fair
3	Curriculum	2. Sequence of BIM topics/learning outcomes	Vocational High School 1 Sedayu	Very Good
			Vocational High School 2 Yogyakarta	Fair
			Vocational High School 3 Yogyakarta	Fair
4	Learning Materials	1. Relevance of BIM learning materials to learning outcomes	Vocational High School 2 Depok	Very Good
		2. Scope of BIM learning materials	Vocational High School 1 Sedayu	Very Good
		3. Compliance with BIM learning materials	Vocational High School 2 Yogyakarta	Fair
Vocational High School 3 Yogyakarta	Fair			
5	Teaching Method	1. BIM learning methods applied considering student interests and potential	Vocational High School 2 Depok	Fair
		2. Student-oriented BIM learning	Vocational High School 1 Sedayu	Very Good
			3. PjBL-oriented BIM learning	Vocational High School 2 Yogyakarta
			Vocational High School 3 Yogyakarta	Fair
		1. Suitability of BIM learning assessment methods	Vocational High School 2 Depok	Poor
			Vocational High School 1 Sedayu	Very Good
6	Learning Evaluation	2. Mastery learning orientation	Vocational High School 2 Yogyakarta	Fair
			Vocational High School 3 Yogyakarta	Fair
		3. Involving users in BIM learning	Vocational High School 3 Yogyakarta	Fair

The results of this study indicate that the implementation of Building Information Modeling (BIM) learning at SMK Yogyakarta in the DPIB Specialization still faces various challenges, ranging from human resources, infrastructure, curriculum, and managerial support. These findings are in line with the opinion (Naufalia, 2023), which states that one of the main obstacles in the application of BIM in education is the lack of experts with skills in BIM, both from a technical and pedagogical perspective.

In terms of human resources, both teachers and students at SMKN 2 Yogyakarta and SMKN 3 Yogyakarta consider that the competence of teachers in teaching BIM is still not optimal. This shows that teachers' mastery of BIM as a competency is still uneven, which hinders the effectiveness of learning. In fact, according to Kamdhi and Jaedun (2022), teachers' mastery of BIM is an important prerequisite for bridging the gap between vocational education and the needs of industry. The facilities and infrastructure aspect also received low to moderate ratings in most schools. This data reinforces the findings (Utomo, 2019) and (Ramadhan et al., 2022) that the low adoption of BIM in Indonesia is due to limitations in technological infrastructure, such as inadequate computer equipment and licensed software that is not yet available evenly. This hinders the 3D digital-based learning process, such as BIM, which requires specific device specifications.

In terms of curriculum and materials, most teachers and students assessed that BIM materials were not fully integrated into the learning structure. This is relevant to the study by Hatmoko et al. (2019), which states that industry standards in the construction field require mastery of BIM, but its integration into the vocational school curriculum is still partial. In fact, based on Kemdikbudristek (2022), BIM technology has begun to be accommodated in Learning Outcomes (CP) for DPIB subjects. This shows a gap between policy and actual implementation in schools.

In addition, in terms of learning methods and evaluation, the data shows a dominance of the "fair" category in all schools. Teachers still tend to use conventional methods and have not widely applied project-based or collaborative approaches, as recommended in the Merdeka Curriculum principles. This contradicts constructivist learning theory and the findings of Aryanti et al. (2020), which show that real projects such as final assignments can significantly improve students' understanding of BIM.

On the managerial side, aspects of leadership and school management support are also uneven. These findings indicate the importance of the role of school leaders in creating an environment that supports BIM development, as emphasized by Naufalia (2023) that collaboration between stakeholders is very important in shaping national BIM standards in Indonesia.

The implementation of Building Information Modeling (BIM) learning in the DPIB Specialization Concentration at SMK Yogyakarta still faces various obstacles stemming from aspects of human resources, facilities and infrastructure, learning curriculum, learning methods, and managerial support. Teachers' competence in BIM mastery is not yet evenly distributed, which affects the effectiveness of learning, while limitations in technological infrastructure and licensed software are obstacles to the implementation of 3D digital-based learning. The curriculum, which is not yet fully integrated with BIM material, shows a gap between policy and implementation at the school level. In addition, conventional teaching methods and the lack of project-based approaches reduce students' potential to master BIM. Suboptimal managerial support also highlights the need for school leadership to create an environment conducive to BIM development.

Therefore, efforts are needed to improve teacher competence, provide adequate facilities and infrastructure, integrate a more comprehensive curriculum, innovate learning methods, and strengthen managerial support to reinforce the implementation of BIM in vocational schools.

## B. Designing the BIM Learning Objective Flow (LOF)

After describing the implementation of BIM in learning at various vocational schools, this study continued with its second objective, which was to formulate a Learning Objective Flow (LOF) as a solution for the systematic and applicable development of BIM learning. The preparation of this LOV was a strategic step to overcome various challenges faced by educational units, such as limited human resources, facilities, and a curriculum that did not fully integrate the BIM approach. The LOF is comprehensively designed to cover learning objectives, achievement indicators, learning activities, and assessments in line with the needs of the modern construction industry. With the LOF, the learning process not only becomes more focused and measurable but also aligns with the spirit of the Merdeka Curriculum and the strengthening of the Pancasila Student Profile. The following are recommendations for the formulation of the BIM Learning LOF based on various vocational schools in Yogyakarta.

**Table 3.**  
Formulation of Learning LOF for BIM

No	Learning Objectives	Achievement Indicators	Learning Activities	Assessment
1	Explaining the basic concepts and benefits of BIM	Explaining the meaning and benefits of BIM in the building design process	Explanation of concepts and interactive discussion	Written test, question and answer session
2	Applying occupational health and safety principles in building design activities	Identifying procedures and hazards in BIM design studios	Case studies, simulations, group discussions	Observations, presentations
3	Using drawing tools and design software according to standards	Identifying manual and digital drawing tools and using them in basic design	Practicing manual and AutoCAD combinations	Observing practices, worksheets
4	Creating 2D technical drawings (floor plans, elevations, sections)	Compiling architectural drawings according to technical symbols and scales	Practical drawing with AutoCAD/SketchUP	Portfolio of drawings
5	Drawing 2D building structures	Compiling drawings of foundations, columns, beams, slabs	Drawing structures manually/digitally	Technical worksheets
6	Designing aesthetically pleasing and contextual building exteriors	Determining facades, lighting, and materials in accordance with local culture	Designing exteriors using graphics software	Visual and functional assessment
7	Designing ergonomic and functional building interiors	Arranging layouts and furniture based on function and aesthetics	Designing interiors with Revit/SketchUP	Design presentations
8	Creating 3D models of buildings (structures and architecture)	Compiling simple and complete 3D models	Modeling practice with SketchUP/Revit	3D model assessment
9	Using BIM technology in building design planning	Integrating architectural and structural drawings into BIM files	Simulation using Revit/ArchiCAD	BIM project assessment
10	Designing public spaces with a local cultural approach	Creating public facility designs that reflect cultural values	Library, office, and gallery space projects	Design portfolio
11	Creating building design visualizations and animations	Producing walkthrough animations and renderings	Visual renderings, digital animation creation	Animated videos, presentations

No	Learning Objectives	Achievement Indicators	Learning Activities	Assessment
12	Evaluating building designs from a sustainability perspective	Identifying green building elements in designs	Case studies and evaluation presentations	Presentation rubrics
13	Compiling technical reports from design results	Creating technical reports containing background information, methods, and results	Independent report writing for projects	Report assessment
14	Collaborating on cross-disciplinary designs	Sharing roles and consolidating work in team projects	Multidisciplinary group projects	Project assessment & collaboration
15	Compiling a professional digital portfolio	Compiling all results into digital format (PDF/Website)	Creating a portfolio or digital exhibition simulation	Final portfolio assessment

The Learning Objective Flow formulated in this study is the result of an analysis of the implementation of Building Information Modeling learning in several vocational schools in the DPIB expertise program. The Learning Objective Flow structure contains learning objectives, achievement indicators, learning activities, and assessments that are designed in stages, starting from mastery of basic BIM concepts to the collaborative project development stage. Thus, this Learning Objective Flow not only serves as a systematic guide for teachers in implementing BIM learning but also as an adaptive and contextual operational framework in line with the needs of the modern construction industry. The following presents the LOF in the form of a systematic flowchart.

The development of Learning Objective Flow (LOF) in the context of Building Information Modeling (BIM) learning in vocational schools is a strategic step to address the challenges of BIM implementation faced by educational units, especially in the Building Modeling and Information Design (DPIB) Concentration. In accordance with the principles of the Merdeka Curriculum, the LOF is designed to build flexible, contextual learning that is oriented towards strengthening the Pancasila Student Profile. The LOF is systematically structured, taking into account the relationship between objectives, achievement indicators, learning activities, and assessments that support 21st-century skills and the needs of the digital construction technology-based world of work.

The LOF structure developed in this study consists of 15 learning objectives arranged in stages, starting from mastering basic BIM concepts to integrative skills in creating professional digital portfolios. This is in line with the opinion of Rini et al. (2023), who emphasize that the LOF must have logical continuity, relevance to the curriculum, and be oriented towards the needs and characteristics of students. For example, in the initial stage, students are invited to understand the basic concepts of BIM and K3LH principles, which are important foundations before entering into practical activities of drawing or digital modeling. Learning activities at this stage are carried out through discussions, case studies, and software introduction.

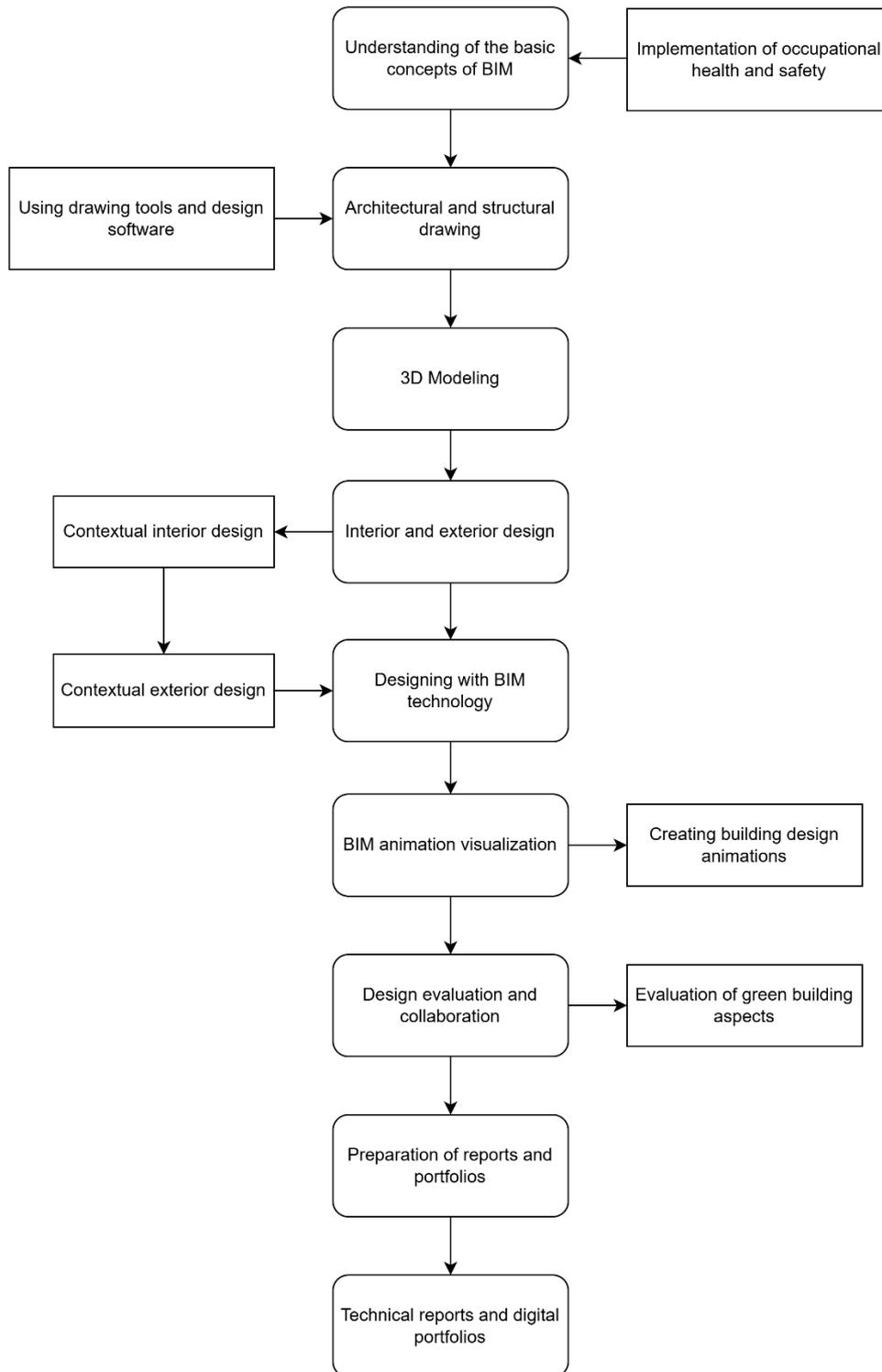


Figure 2. Learning Objective Flow

At the intermediate stage, the LOF guides students to master 2D and 3D drawing skills, both manually and digitally, with the support of software such as AutoCAD, SketchUp, and Revit. This mastery is the core competency of DPIB learning, which is in line with the learning outcomes in the Merdeka Curriculum. Here, students are involved in technical

exercises and practical projects to compile floor plans, elevations, sections, building structures, and interior and exterior designs. According to the Ministry of Education, Culture, Research, and Technology (2024), effective LOF must be able to translate learning outcomes into challenging and meaningful activities and can shape students' factual, procedural, and metacognitive skills.

Furthermore, at the advanced stage, students are facilitated to integrate the skills they have learned through more complex BIM projects, such as designing buildings based on local culture, animation visualization, and evaluating the sustainability aspects of buildings. These activities not only require technical skills but also critical thinking, collaboration, and visual communication skills, which are important elements in strengthening vocational competencies. In this context, assessment is carried out not only individually but also through group project-based assessments, presentations, and digital portfolios. This assessment approach supports the formation of students' character as independent, collaborative, and adaptive learners.

The integration of sustainability principles and local values in public space design shows that the LOF is not only technical but also contextual and culturally valuable. This is in line with the characteristics of the Merdeka Curriculum, which encourages learning that is relevant to real life and the surrounding environment. In addition, the compilation of digital portfolios as the final output of learning is also in line with the needs of modern industry, which requires graduates to have a professionally documented track record of their work.

Thus, the LOF formulated in this study not only functions as a learning planning tool but also as a strategic instrument in directing the learning process to be more meaningful, focused, and in line with the development of BIM technology and the needs of the world of work. The systematic and learning-outcome-oriented development of BIM-based LOFs is a tangible contribution to strengthening schools' readiness to deliver innovative and highly competitive vocational learning.

## CONCLUSION

Based on the results of research conducted at four educational institutions, namely SMKN 2 Depok, SMKN 1 Sedayu, SMKN 2 Yogyakarta, and SMKN 3 Yogyakarta, in the Building Information Modeling and Design (DPIB) concentration, the implementation of Building Information Modeling (BIM) learning shows significant variations between schools. These findings reflect the actual conditions of Building Information Modeling (BIM) learning implementation, which still faces various challenges in terms of human resources, supporting infrastructure, curriculum integration, and learning strategies applied.

The implementation of BIM learning in the DPIB specialization at vocational schools in Yogyakarta shows uneven trends. SMKN 2 Depok and SMKN 1 Sedayu show a relatively good level of implementation, especially in terms of human resources, facilities, and infrastructure, and learning materials. Conversely, SMKN 2 Yogyakarta and SMKN 3 Yogyakarta show a relatively low level of implementation. This is particularly evident in the aspects of teacher competence in the use of BIM, the availability of software and hardware, and learning methods that are not yet oriented towards a collaborative or project-based approach.

In response to these implementation challenges, this study has formulated a BIM Learning Objective Flow (ATP) that is systematic, contextual, and adaptive to the principles of the

Merdeka Curriculum. The development of this ATP not only serves as a guide for more focused and measurable learning planning but also as a strategic instrument in directing the learning process relevant to the needs of the digital construction industry and strengthening the character of students through the integration of local culture, environmental sustainability, and the development of professional digital portfolios.

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