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The Effect of PjBL Model Assisted by Revit Application on Students' Building Drawing Learning Outcomes in the DPIB Department at SMK Negeri 4 Palembang

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Abstract: Building drawing instruction in vocational secondary schools (SMK) continues to face significant challenges, particularly low student learning outcomes attributed to teacher-centered approaches and suboptimal integration of industry-relevant technology. This study aims to analyze the differences in building drawing learning outcomes across cognitive, psychomotor, and affective domains between students taught using the Project Based Learning (PjBL) model assisted by Revit and those receiving conventional instruction in the DPIB department at SMK Negeri 4 Palembang. A quantitative quasi-experimental design with Non-Equivalent Control Group and pretest–posttest procedure was employed. Subjects were Grade XII DPIB students in the 2024/2025 academic year: experimental group (n = 32) and control group (n = 30). Data were collected through cognitive tests, project assessment rubrics, and attitude questionnaires, then analyzed using independent and paired sample t-tests after fulfilling normality and homogeneity requirements, with effect size measured by Cohen's d. The PjBL-Revit model was implemented at a very good level (88.89%). Cognitive outcomes differed significantly between experimental (M = 89.91) and control groups (M = 67.27), with $p < 0.05$ and a very large effect size (Cohen's d = 4.74). Psychomotor outcomes also differed significantly (experimental: M = 77.95 vs. control: M = 65.40), as did affective outcomes (experimental: M = 3.14/4.00 vs. control: M = 2.71/4.00). These findings confirm that PjBL assisted by Revit not only enhances technical drawing competencies but also aligns vocational training with digital construction industry standards.

Keywords: BIM; Learning outcomes; Project-Based Learning; Revit; Vocational education.

Introduction

Vocational secondary education, known in Indonesia as Sekolah Menengah Kejuruan (SMK), is specifically designed to equip students with occupational competencies and professional readiness for the world of work. Unlike general education, vocational learning must integrate theoretical knowledge with authentic work experiences, enabling students to develop technical skills and professional attitudes simultaneously. This principle aligns with Experiential Learning Theory (ELT), which holds that knowledge is constructed through the transformation of experience rather than the passive reception of information. Empirical scholarship consistently confirms that experience-based approaches are particularly effective in vocational contexts, as they bridge the gap between conceptual understanding and practical, industry-relevant competence (Anindya et al., 2026). In this regard, both the pedagogical model employed and the technological tools integrated into instruction are critical determinants of learning quality in SMK settings (Sihite & Medan, 2024).

In the field of building design and construction, the rapid advancement of digital technology has fundamentally transformed professional practice.

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Building Information Modeling (BIM) has emerged as the prevailing standard in architectural planning, structural design, and construction project management. Data from Indonesia's Ministry of Public Works and Housing (Kementerian PUPR, 2023) indicate a consistent upward trajectory in BIM adoption within the domestic construction industry, rising from approximately 10% in 2015 to 38% by 2023, while reliance on traditional two-dimensional CAD workflows has progressively declined. This technological shift reflects a structural transformation in the competency profile demanded of construction professionals: graduates must now demonstrate not only technical drawing proficiency but also fluency in data-driven, digitally integrated design processes (Attamimi & Handayani, 2025). Consequently, SMK programs particularly those within the Design, Modeling, and Building Information (DPIB) department face mounting institutional pressure to realign their instructional practices with current and emerging industry standards (Pratama & Khumaedi, 2026).

Despite this urgency, building drawing instruction in the majority of SMK settings remains predominantly teacher-centered, affording students limited opportunities for active inquiry, autonomous decision-making, and complex project engagement. Students frequently demonstrate difficulties in comprehending holistic building design concepts, maintaining precision in technical drawing execution, and working independently on multistep drafting tasks (Desky et al., 2025; Gusma et al., 2025). More critically, the deployment of digital design applications in classroom settings is largely confined to procedural tool operation students learn to execute commands without being embedded in the complete workflow of a real-world project. This procedural, decontextualized use of technology fails to develop the higher-order cognitive and practical competencies that professional construction contexts demand, and consequently produces suboptimal learning outcomes across cognitive, psychomotor, and affective domains (Habib et al., 2026).

SMK Negeri 4 Palembang, which operates a DPIB program, exemplifies this institutional tension. The school possesses adequate physical and digital learning infrastructure, including licensed access to Autodesk Revit; however, student performance in building drawing remains consistently below expected competency benchmarks, particularly in terms of conceptual accuracy, drawing precision, and task independence. This disparity between available facilities and actual learning outcomes indicates that the core problem is not one of resource insufficiency but rather of instructional model inadequacy (Vanorika et al., 2016). Specifically, the existing use of Revit at the institution is limited to procedural demonstrations rather than being integrated into a structured, project-based learning framework that would compel students to engage with the full design process (Meliana et al., 2020). This gap between technological potential and pedagogical realization constitutes the operational problem motivating the present study (Wigunha, 2024).

A substantial body of empirical literature supports Project Based Learning (PjBL) as a pedagogically appropriate and effective model for vocational education. PjBL engages students in the planning, execution, and reflective evaluation of authentic, real-world projects that simulate genuine industry conditions. Through sustained project engagement, students develop critical thinking, collaborative problem-solving, and transferable technical skills competencies that are directly aligned with professional practice expectations (Ningsih et al., 2025). The seven-step PjBL framework specifically tailored to vocational education contexts, encompassing stages from formulating learning objectives and understanding conceptual foundations through to project execution, presentation, and structured evaluation. This framework ensures that project experiences are pedagogically controlled and competency-oriented rather than merely task-driven, providing a principled basis for instructional design in SMK settings (Sudianti et al., 2025).

The integration of PjBL with BIM technology specifically through the Autodesk Revit application represents a powerful convergence of pedagogical method and industry-relevant technological tool. Revit enables students to construct parametric three-dimensional building models that are dynamically linked to two-dimensional working drawings and technical documentation, closely replicating professional construction workflows (Habib et al., 2025). When embedded within a PjBL framework, Revit transforms the learning environment into an authentic digital workspace in which students engage iteratively in project planning, collaborative three-dimensional modeling, design revision, and professional-standard presentation. This integration operationalizes the principle of situated learning, wherein durable understanding is constructed through active participation in contextually realistic, professionally meaningful practices (Habib et al., 2026). The resulting learning environment is thus simultaneously pedagogically structured and professionally authentic.

Prior research has examined components of this integration in partial and fragmented ways. Revit used as a standalone learning medium positively influenced building construction learning outcomes at an SMK in Jakarta, though without a structured pedagogical framework. Ermawalis et al. (2025) reported that the STAD cooperative model combined with Revit video tutorials produced significantly higher posttest scores relative to conventional instruction. Maulia and Apdeni (2024) documented an 83% effectiveness rate for BIM-based instruction using ArchiCAD among DPIB students. While these contributions are valuable, none has examined the combined and systematic effect of a structured seven-step PjBL model and the Revit application on learning outcomes simultaneously across cognitive, psychomotor, and affective domains within a controlled quasi-experimental design. This represents a substantive empirical gap. The novelty of the present study lies in its integration of a theoretically grounded vocational PjBL framework with an industry-standard BIM tool, evaluated comprehensively across three learning domains an approach that more fully addresses the competency demands of contemporary construction education than any prior single-domain or single-method investigation.

The urgency of this research is further underscored by the broader policy context of Indonesian vocational education reform. The national Link and Match agenda which mandates closer alignment between SMK curricula and industry competency standards explicitly requires that vocational graduates possess digital literacy and technological fluency commensurate with current professional practice (Kemendikbudristek, 2022). Within the construction sector, BIM proficiency has been identified as a core graduate competency by major industry stakeholders, yet its systematic integration into structured vocational pedagogy remains nascent. This study therefore addresses not only a pedagogical gap in the academic literature but also a practical gap in the professional preparation of DPIB graduates. By empirically validating a PjBL-Revit instructional model within a quasi-experimental design, this study provides evidence-based guidance for curriculum developers, vocational teachers, and educational policymakers seeking to modernize building drawing instruction in alignment with the digital construction industry.

This study therefore aims to analyze the differences in cognitive learning outcomes between students taught using the PjBL model assisted by the Revit application and those receiving conventional instruction, while also evaluating the quality of psychomotor and affective learning outcomes achieved by students in the experimental group within the DPIB department at SMK Negeri 4 Palembang. Based on the theoretical framework and prior empirical evidence, the following hypotheses are proposed: (1) there is a statistically significant difference in cognitive learning outcomes between the experimental group and the control group; (2) psychomotor learning outcomes of the experimental group, as assessed through Revit-based project rubrics, fall within the good to very good category, indicating adequate practical competency development; and (3) affective learning outcomes of the experimental group reflect a positive student disposition toward project-based, technology-integrated learning, consistent with the professional attitudes required in digitally-driven construction practice.

Method

Research Approach and Design

This study employed a quantitative approach using a quasi-experimental method. A quasi-experimental design was selected because random assignment of subjects was not feasible, as classes in the school setting had been administratively formed prior to the study. Specifically, the study adopted a Non-Equivalent Control Group Design with a pretest–posttest procedure, involving two intact classroom groups: an experimental group receiving the PjBL model assisted by the Revit application, and a control group receiving conventional instruction using the existing school approach, which employs teacher-directed two-dimensional CAD-based drawing using AutoCAD software without project-based task structures.

This design enabled systematic comparison of learning outcomes between the two groups before and after the instructional intervention (Deviana et al., 2025). It is important to note that while cognitive outcomes were assessed comparatively across both groups using pre- and posttest instruments, psychomotor and affective outcomes were measured descriptively within the experimental group only. This decision reflects the fact that the psychomotor instrument a Revit-based project rubric is inherently tied to the PjBL-Revit workflow and is not applicable to the conventional instruction context. Accordingly, the research objectives for psychomotor and affective domains are framed as descriptive performance evaluations of the experimental group, rather than comparative hypothesis tests.

Research Setting and Schedule

The study was conducted at SMK Negeri 4 Palembang, a state vocational secondary school operating a Design, Modeling, and Building Information (DPIB) program in Palembang, South Sumatra, Indonesia. Data collection took place during the even semester of the 2025/2026 academic year. The instructional intervention spanned eight structured meetings with a total teaching allocation of 44 instructional hours (JP), equivalent to 1,980 minutes, scheduled across the period of 2 March to 12 March 2026.

Preparatory activities, including instrument development and expert validation, were conducted in February 2026, while data analysis was completed in March 2026.

It is acknowledged that delivering eight instructional meetings within an eleven-calendar-day window places substantial scheduling demands on both students and instructors. This condensed timeline was made feasible by the fact that the DPIB program at SMK Negeri 4 Palembang allocates a high weekly contact hour load to building drawing subjects with DPIB specific instruction scheduled on multiple consecutive days within the academic timetable. Furthermore, the PjBL framework implemented here follows the structured seven-step vocational model proposed, in which the foundational conceptual and skills-practice phases (Meetings 1–3) are explicitly sequenced to support efficient onboarding into Revit-based project work. Students in the DPIB program had prior exposure to basic digital drawing tools, which reduced the learning curve for procedural Revit operations and rendered the project execution phase (Meetings 4–7) achievable within the allocated timeframe. The final meeting was dedicated to project presentation and reflective evaluation. Future replication studies are encouraged to extend the intervention to a minimum of four weeks to allow for more iterative project development cycles.

Population and Sample

The population of this study comprised all Grade XII DPIB students at SMK Negeri 4 Palembang in the 2025/2026 academic year. Two intact classes were selected as the research subjects using purposive sampling based on demonstrated class equivalence in terms of curriculum coverage, instructional schedule, and assigned subject teacher. Class XII DPIB 1, consisting of 32 students, served as the experimental group and received instruction using the PjBL model assisted by the Revit application. Class XII DPIB 2, consisting of 30 students, served as the control group and received conventional instruction as typically practiced at the school — specifically, teacher-centered direct instruction using AutoCAD for two-dimensional building drawing tasks, without project-based learning structures or BIM integration

Operational Definition of Variables

The independent variable in this study was the PjBL model assisted by the Revit application, operationally defined as a project-based learning approach implemented through seven structured syntactic stages: (1) formulating expected learning outcomes and product specifications; (2) understanding BIM conceptual content; (3) practicing fundamental Revit skills; (4) designing the project theme and forming collaborative teams; (5) developing a project proposal; (6) executing the project tasks; and (7) presenting and reporting project results. Implementation fidelity was assessed using an observation checklist comprising 27 operational indicators mapped across eight instructional meetings.

The dependent variable was building drawing learning outcomes, measured across three domains. The cognitive domain referred to students' conceptual understanding of building drawing principles, BIM workflows, and Revit-based design processes, assessed comparatively across both the experimental and control groups. The psychomotor domain referred to students' practical skill in producing parametric building models and working drawings using the Revit application, assessed descriptively within the experimental group through a project-based rubric. The affective domain referred to students' attitudes and behavioral dispositions during project-based learning encompassing motivation, independence, collaboration, responsibility, and perceived relevance to the construction industry assessed descriptively within the experimental group using a structured questionnaire. The separation of comparative and descriptive measurement across domains is explicitly aligned with the study's instrumentation design, in which the psychomotor and affective instruments were developed specifically for the PjBL-Revit instructional context and are not applicable to conventional instruction assessment.

Research Instruments

Four instruments were used in this study. First, a cognitive test in the form of a 30-item multiple-choice pretest–posttest was developed based on a content specification grid covering six domains: BIM concepts, parametric modeling, view and documentation, project settings, annotation and drawing standards, and basic Revit workflow. Items were distributed across cognitive levels C2 through C4 following the revised Bloom's taxonomy. Content validity was established through expert judgment using the Scale-level Content Validity Index (S-CVI). Item reliability was calculated using the Kuder–Richardson 20 (KR-20) formula the appropriate reliability estimator for dichotomously scored items yielding a coefficient of 0.81, classified in the high reliability category.

Second, a project assessment rubric comprising nine analytical scoring aspects was used to measure psychomotor outcomes within the experimental group. The aspects assessed included: the quality of the Revit model at Stage I (simple one-story building), project proposal and planning, project file setup and structure, modeling accuracy of geometry and parameters, team collaboration and model integration, technical conformity with the project brief, completeness and quality of 2D and 3D working drawing outputs, and individual and team project presentation quality. Each aspect was scored on a four-point scale with operationally defined behavioral descriptors. To establish inter-rater reliability, the rubric was independently applied by two raters the researcher and the class teacher to a randomly selected subset of 10 student project outputs. Inter-rater agreement was calculated using Cohen's Kappa, yielding a coefficient of $\kappa = 0.83$, indicating strong agreement. The full dataset was then scored by the primary rater, with the established reliability coefficient reported.

Third, an attitude and perception questionnaire consisting of 20 items measured on a four-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree) was administered to assess affective learning outcomes within the experimental group. A four-point scale was deliberately selected to eliminate the neutral midpoint and compel directional responses. The questionnaire covered five dimensions: attitude and interest toward Revit-based learning, learning independence, technical digital autonomy, team collaboration, and professional responsibility. Both positively and negatively worded items were included, with negative items reverse-scored prior to analysis. Individual item scores were summed to produce a total score per respondent, which was then converted to a percentage of the maximum possible score and interpreted against a four-tier categorical scale: very positive (86–100%), positive (76–85%), sufficient (60–75%), and negative (< 60%). Cronbach's Alpha reliability analysis yielded a coefficient of $\alpha = 0.868$, classified in the very high reliability category.

Fourth, a structured observation checklist was used by an independent observer the DPIB Program Head to assess the fidelity of PjBL implementation across all 27 operational indicators during each of the eight instructional meetings. The observer had no evaluative role in student assessment to ensure independence of implementation monitoring.

Data Collection Procedure

Data collection followed a structured experimental procedure organized into three phases. In the pre-intervention phase, both the experimental and control groups completed a 30-item cognitive pretest to establish baseline equivalence in conceptual knowledge. In the intervention phase, the experimental group received eight sessions of PjBL-based instruction integrated with the Revit application, while the control group received eight sessions of conventional AutoCAD-based instruction under the same teacher and subject content framework. An independent observer monitored PjBL implementation fidelity during each session using the structured observation checklist.

In the post-intervention phase, both groups completed the cognitive posttest. Additionally, students in the experimental group submitted their completed Revit-based project outputs for psychomotor assessment, and completed the affective attitude questionnaire. The decision to administer psychomotor and affective instruments exclusively to the experimental group is consistent with the study's design rationale: the project rubric requires completion of a Revit-based deliverable, which is not produced under conventional instruction, and the attitude questionnaire is specifically anchored to PjBL-Revit learning experiences. This instrumentation asymmetry is therefore an intentional design feature, not an oversight, and is reflected in the study's hypotheses and data analysis plan.

Data Analysis Technique

Data were analyzed using IBM SPSS Statistics software at a significance level of $\alpha = 0.05$. Descriptive statistical analysis was first conducted to summarize mean scores, standard deviations, minimum and maximum values, and score distributions for each variable and group.

Prior to inferential testing, two prerequisite assumption tests were performed. Normality of score distributions for each group was assessed using the Shapiro–Wilk test. Although the total sample size in this study is $N = 62$ ($n_1 = 32$; $n_2 = 30$), Shapiro–Wilk was selected over Kolmogorov–Smirnov because it is consistently reported in the methodological literature as more statistically sensitive to departures from normality, even at sample sizes exceeding 50, and remains appropriate when each group's n is below 50. Homogeneity of variance between the two groups was examined using Levene's Test for Equality of Variances.

For hypothesis testing, two inferential procedures were applied to cognitive outcomes. The paired sample t-test was used to compare pretest and posttest scores within each group to evaluate within-group learning gains. The independent sample t-test was used to compare posttest scores between the experimental and control groups to test for between-group differences. To quantify the practical significance of observed cognitive differences, effect size was calculated using Cohen's d, with values interpreted as small ($d < 0.2$), medium ($d = 0.5$), or large ($d \geq 0.8$).

Psychomotor data from the project rubric and affective data from the questionnaire were analyzed descriptively for the experimental group only. Rubric scores were computed as mean values per assessment dimension and interpreted against the four-point categorical scale. Affective questionnaire scores were converted to percentage scores and classified using the four-tier interpretive scale described in the instruments section (very positive, positive, sufficient, negative). This descriptive approach is consistent with the absence of a comparable control group dataset for these two domains. Observation data on PjBL implementation fidelity were analyzed as a percentage of indicators confirmed as implemented, classified on a four-tier scale: very good (86–100%), good (76–85%), sufficient (60–75%), and poor (< 60%).

Result and Discussion

Result

Define Stage

The quasi-experimental design applied in this study is summarized in Table 1, illustrating the group structure, treatment conditions, and measurement points used throughout the study.

Table 1. Experimental Design.

Group	Pretest	Treatment	Posttest
Experimental (XII DPIB 1, n = 32)	T1	PjBL + Revit Application	T2
Control (XII DPIB 2, n = 30)	T1	Conventional Learning	T2

Implementation of the PjBL Model Assisted by Revit Application

The first finding concerns the fidelity of PjBL implementation as observed across all eight instructional meetings. Results showed that the model was carried out at an overall rate of 88.89%, classified as very good, indicating that the instructional procedures were implemented consistently and in accordance with the planned learning syntax. This high level of implementation fidelity reflects the effectiveness of the designed learning scenario in guiding both teacher and student activities throughout the learning process. Table 2 presents the implementation rate per syntactic stage, providing a more detailed breakdown of how each phase of the PjBL model was executed in practice.

Table 2. PjBL Implementation Observation Results per Syntactic Stage

Mtg	Syntactic Stage	Indicators	Implemented	Percentage %
1	Formulating Learning Outcomes & Product Specifications	3	3	100
2	Understanding BIM Conceptual Content	2	2	100
3	Practicing Fundamental Revit Skills	2	2	100
4	Designing Project Theme & Proposal	5	5	100
5	Project Proposal (cont.) & Project Execution	6	5	83.34
6	Project Execution (cont.)	5	4	80.00
7	Project Monitoring & Finalization	4	3	75.00
8	Presentation & Reporting	4	4	100
Total	8 Stages 27 Indicators	27	24	88.89

The stages of formulating learning outcomes, conceptual understanding, skills training, project design, and final presentation each achieved 100% implementation, reflecting the structured preparation of instructional materials and the teacher's familiarity with PjBL procedures. The relatively lower rates observed in the project execution and monitoring stages (75–83.34%) are attributable to the technical complexity of collaborative Revit modeling and time constraints during model integration and revision processes. This pattern is consistent with Kokotsaki et al. (2021), who noted that the monitoring phase in PjBL demands more intensive facilitation as students navigate increasingly complex project tasks. The overall implementation rate of 88.89% confirms that the intervention was delivered with high fidelity, lending methodological credibility to the subsequent outcome analyses

Prerequisite Analysis Tests

Before hypothesis testing, normality and homogeneity of the posttest data were examined. Results are presented in Table 3 and Table 4.

Table 3. Shapiro–Wilk Normality Test Results

Class	Data	Shapiro-Wilk		
		Statistic	df	Sig
Experiment	PreTest	0.874	32	0.001
	PostTest	0.943	32	0.091
Control	PreTest	0.947	30	0.138
	PostTest	0.947	30	0.138

Table 4. Levene's Homogeneity Test Results

Velue	Levene Statistic	df1	df2	Sig.
Post-tes	0.314	1	60	0.578

Posttest data from both groups satisfied the normality assumption ($p > 0.05$), and variance homogeneity was confirmed ($p = 0.578 > 0.05$). Although the experimental group's pretest data were not normally distributed, this did not affect hypothesis testing, as inferential analysis was performed exclusively on posttest scores representing post-intervention achievement. The fulfilled assumptions validated the use of parametric statistical testing

Cognitive Learning Outcomes

Descriptive statistics and hypothesis test results for cognitive learning outcomes are presented in Table 5 and Table 6.

Table 5. Descriptive Statistics of Pretest and Posttest Scores

Velue	Pretest Mean	Posttest Mean	N-Gain	Students Achieving KKM.
Experimental (n= 32)	47.19	89.91	+42.72	32 (100%)
Control (n = 30)	38.33	67.27	+28.94	0 (0%)

Table 6. Independent Sample t-Test and Effect Size Results

Levene's Test for Equality of Variances		t- Test for Equality of Means		
	F	Sig.(2-tailed)	T	Df
Equal Variances Assumed	0.126	0.00	4.740	60
Equal Variances Assumed		0.00	18.653	4.740

The experimental group achieved a posttest mean of 89.91, substantially higher than the control group's mean of 67.27, with all 32 experimental students reaching the minimum competency threshold (KKM), compared to none in the control group. The independent sample t-test confirmed a statistically significant difference ($p < 0.05$), and Cohen's d of 4.740 indicates a large practical effect size. Figure 1 illustrates the mean score comparison between groups across both measurement points.

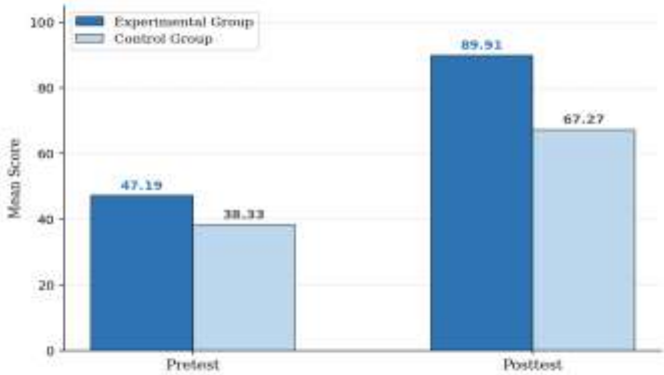

Figure 1. Comparison of Mean Cognitive Scores Between Experimental and Control Groups

These findings align with Experiential Learning Theory, which holds that knowledge is constructed through active engagement and reflective experience rather than passive reception. Within the PjBL–Revit learning environment, students progressed through concrete experience (Revit modeling), reflective observation (peer and teacher feedback), abstract conceptualization (BIM principles), and active experimentation (project revision), thereby completing the full experiential learning cycle in a structured and meaningful manner. This cyclical process indicates that learning is not only procedural but also deeply conceptual, as students continuously refine their understanding through iterative practice and reflection. From a Zone of Proximal Development perspective (Vygotsky), scaffolded support provided by the teacher, along with collaborative team structures, enabled students to accomplish tasks beyond their individual capacity, thereby strengthening both cognitive engagement and technical proficiency in BIM-based design tasks (Irfan et al., 2025).

Furthermore, these results are consistent with previous empirical studies that emphasize the effectiveness of technology-integrated, student-centered learning models. (Fiona et al., 2025) reported significantly higher posttest scores in experimental groups utilizing technology-based learning compared to conventional instruction, highlighting the positive impact of active learning environments on student achievement. Similarly, demonstrated that the use of Revit-based instructional media significantly improves learning outcomes in building construction subjects by enhancing students' spatial understanding and technical skills. Collectively, these studies reinforce the present findings that the integration of PjBL and Revit within a structured learning framework not only improves conceptual comprehension but also fosters practical competence and professional readiness in vocational education contexts.

Psychomotor Learning Outcomes

Psychomotor performance was assessed through the Revit-based project rubric across nine analytical dimensions. Results are summarized in Table 7.

Table 7. Descriptive Statistics of Project Assessment per Dimension (Experimental Group)

Assessment Dimension	Mean Score	Max Score	Category
Revit Model – Stage I (Simple Building)	3.03	4.00	Good
Project Proposal & Planning	3.16	4.00	Good
Project File Setup & Revit Structure	2.69	4.00	Sufficient
Modeling Accuracy – Geometry, Dimension & Parameters	3.06	4.00	Good
Team Collaboration & Model Integration	3.25	4.00	Good
Technical Conformity with Project Brief	3.13	4.00	Good
Completeness & Quality of 2D & 3D Working Drawings	3.03	4.00	Good
Project Presentation – Technical Delivery	3.47	4.00	Very Good
Project Presentation – Individual Contribution	3.72	4.00	Very Good
Overall Mean	77.95 / 100	–	Good

The overall mean project score of 77.95 out of 100 falls within the good category, with score distribution revealing that 6 students (18.8%) achieved very good, 20 students (62.5%) achieved good, and 6 students (18.8%) required further improvement. The highest-scoring dimensions were individual contribution in project presentation (M = 3.72) and technical delivery (M = 3.47), reflecting the effectiveness of the final PjBL stage in developing students' ability to communicate design decisions professionally and account for their individual modeling contributions. The lowest-scoring dimension was project file setup and Revit structure initialization (M = 2.69), indicating that the early technical configuration of Revit projects — including template settings, coordinate systems, levels, and grids — remains a challenging area requiring more intensive foundational practice.

These findings support the situated learning framework (Taali et al., 2024), wherein authentic task environments generate meaningful skill development. The Revit application functioned not merely as a drafting tool, but as a professional workflow simulator, enabling students to experience the complete BIM process from project initiation to documented output. This is consistent with (Habib et al., 2025), who argued that BIM-based learning environments foster holistic understanding of building design by integrating parametric modeling with technical documentation. Similarly affirmed that project-based vocational learning is associated with stronger practical competence development when students engage in complete, industry-relevant production cycles.

Affective Learning Outcomes

Student attitudes and perceptions toward the PjBL–Revit learning experience were measured across five dimensions. Results are presented in Table 8 and Figure 2.

The overall affective mean of 3.14 out of 4.00 (78.5%) indicates a generally positive student response to the PjBL–Revit instructional model. The highest-scoring dimension was career relevance and BIM industry perception (M = 3.50, very positive), demonstrating that students possess a strong awareness of BIM competency as a professional asset in the modern construction workforce. This finding is educationally significant, as intrinsic motivation linked to perceived career relevance is a critical driver of sustained learning engagement in vocational education.

Table 8. Mean Scores of Affective Questionnaire per Dimension (Experimental Group)

Dimension	Mean Score	Percentage %
Attitude & Interest toward Revit-Based Learning	3.08	77.0
Learning Independence	2.85	71.3
Technical Digital Autonomy	2.87	71.8
Team Collaboration	3.25	81.3
Professional Responsibility	3.28	82.0
Career Relevance & BIM Industry Perception	3.50	87.5
Overall	3.14	78.5

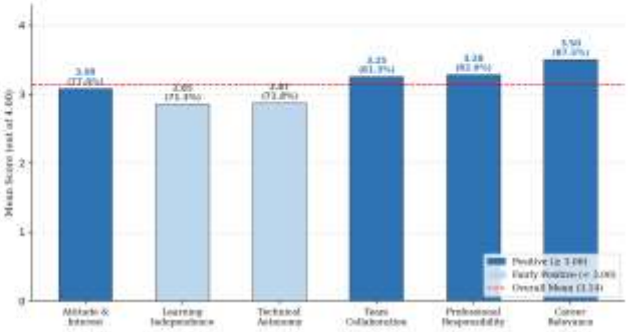

Figure 2. Mean Affective Scores per Dimension (Experimental Group)

The dimensions of professional responsibility (M = 3.28) and team collaboration (M = 3.25) also reflected positive student attitudes, indicating that the structured collaborative demands of PjBL effectively fostered accountability and cooperative working behaviors. These dispositions are consistent with the professional character formation goals articulated in Indonesia's vocational curriculum framework (Kemendikbudristek, 2022) and align, who emphasized that project-based vocational learning develops not only technical competence but also collaborative and responsible work attitudes.

Conversely, learning independence (M = 2.85) and technical digital autonomy (M = 2.87) received the lowest scores, both in the fairly positive category. This pattern suggests that a subset of students remained in an adaptive phase of Revit skill acquisition, requiring guided support to independently troubleshoot software issues and navigate advanced tool functions. This is an expected outcome given the relative novelty and complexity of BIM software in the SMK context, and underscores the importance of sustained foundational training before students engage with complex project modeling. Similarly noted that while student motivation toward Revit-based learning is high, technical independence requires continuous scaffolded practice and infrastructure support to develop fully.

Taken together, the results across cognitive, psychomotor, and affective domains provide convergent evidence that the PjBL model assisted by the Revit application yields meaningfully superior learning outcomes compared to conventional instruction. The integration of a structured project-based framework with industry-standard BIM technology creates a learning environment that is simultaneously conceptually rigorous, technically authentic, and professionally motivating — precisely the combination that vocational building education requires in the era of digital construction.

Conclusion

This study investigated the effect of the Project Based Learning (PjBL) model assisted by the Revit application on building drawing learning outcomes across cognitive, psychomotor, and affective domains among Grade XII DPIB students at SMK Negeri 4 Palembang. Three principal conclusions are drawn from the findings. First, the PjBL model assisted by the Revit application was implemented with high fidelity, achieving an overall implementation rate of 88.89% across eight instructional meetings and 27 observed indicators, classified in the very good category. This confirms that the structured seven-stage PjBL framework is operationally viable within a vocational BIM-based learning context. Second, a statistically significant difference in cognitive learning outcomes was found between the experimental group (M = 89.91) and the control group (M = 67.27), with $p < 0.05$ and a large practical effect size (Cohen's d = 4.74). All 32 students in the experimental group achieved the minimum competency threshold, compared to none in the control group. These results demonstrate that integrating PjBL with Revit-based BIM technology substantially enhances conceptual understanding of building drawing principles beyond what conventional instruction achieves. Third, psychomotor outcomes in the experimental group reached a mean project score of 77.95 out of 100 (good category), reflecting students' capacity to produce industry-relevant building models and working drawings through collaborative Revit-based projects. Affective outcomes yielded an overall mean of 3.14 out of 4.00 (78.5%, positive category), with the career relevance and BIM industry perception dimension scoring highest (M = 3.50, very positive), indicating strong student awareness of BIM competency as a professional necessity. Taken together, these findings confirm that the PjBL model assisted by the Revit application significantly improves building drawing learning outcomes in vocational secondary education, simultaneously advancing cognitive understanding, practical skill, and professional attitude formation. Based on the findings and limitations of this study, several recommendations are proposed. For DPIB teachers, it is recommended to adopt the PjBL–Revit instructional model in building drawing courses, with particular emphasis on strengthening the foundational Revit skills training phase before students enter complex project modeling stages. The use of transparent rubrics from the outset of learning is essential to help students internalize quality standards. For school management, investment in adequate computing infrastructure with licensed Revit software is a prerequisite for sustainable BIM-based learning implementation, alongside continuous teacher professional development in both PjBL facilitation and BIM technology. For future researchers, it is recommended to employ true experimental designs with randomization to strengthen internal validity, expand the research scope to multiple schools with diverse characteristics, incorporate longitudinal measurement to track learning sustainability, and combine quantitative and qualitative approaches to capture a more comprehensive picture of the learning process. Additionally, exploring the application of PjBL–Revit integration at higher vocational education levels would further extend the evidence base for BIM pedagogy in Indonesia.

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Authors Contribution
Conceptualization and methodology, H. L. B.; software, validation, formal analysis, and investigation, H. L. B. and A.; data curation, H. L. B. and A.; writing—original draft preparation, H. L. B., A. and R.; writing—review and editing, R.

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There is no conflict of interest.

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