



Development of a Flipbook-Based E-Module with Project-Based Learning (PjBL) Model in the Subject of Ship Outfit Construction (3D Modelling) at SMKN 5 Batam

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Abstract: This research was motivated by the gap between vocational education graduates' The mismatch between vocational education outcomes and industry demands remains a significant challenge, as reflected in the high unemployment rate among vocational high school graduates. In the Ship Outfit Construction subject at SMKN 5 Batam, learning is still predominantly teacher-centered, resulting in low student engagement, critical thinking, problem-solving skills, and limited availability of interactive digital learning resources. Despite the growing adoption of Project-Based Learning (PjBL), studies integrating PjBL with flipbook-based digital modules in vocational maritime education remain limited. Therefore, this study aimed to develop and evaluate the validity, practicality, and effectiveness of a Flipbook-based E-Module integrated with the PjBL model. This Research and Development (R&D) study employed the ADDIE model and a mixed-method approach with a quasi-experimental nonequivalent control group design. The sample consisted of 40 students, divided equally into experimental and control groups. Research instruments included expert validation sheets, practicality questionnaires, learning achievement tests, and 4C skills assessment instruments. Data were analyzed using descriptive statistics, effect size analysis, and MANOVA. The results showed that the developed E-Module was valid and highly practical based on teacher and student evaluations. Furthermore, the experimental group demonstrated significantly higher learning outcomes and 4C skills than the control group, with a large effect size (Cohen's $d = 2.87$) and significant multivariate differences ($F = 97.203, p < 0.001$). These findings indicate that the Flipbook-based PjBL E-Module is an effective learning resource for enhancing vocational students' competencies and 21st-century skills

Keywords: Flipbook-Based E-Module; Project-Based Learning (PjBL); Ship Outfit Construction; Vocational Education; 4C Skills.

Introduction

The quality of vocational education in Indonesia faces significant challenges, as evidenced by the persistently high unemployment rate among Vocational High School (SMK) graduates. Data from the Badan Pusat Statistik (2024) show that graduates of vocational high schools (SMK) continue to record the highest unemployment rate among all educational levels in

Indonesia. This condition indicates a persistent mismatch between the competencies developed in vocational education and the skills required by industry (Gustina et al., 2024). In an era characterized by rapid technological advancement and industrial transformation, vocational education is expected not only to equip students with technical expertise but also to foster higher-order thinking and 21st-century skills

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that enhance graduates' employability and adaptability (Dini & Medan, 2024).

At SMKN 5 Batam, particularly in the Ship Design and Construction Department, learning in the Ship Outfit Construction (Konstruksi Perlengkapan Badan Kapal – KPBK) subject remains largely teacher-centered, relying heavily on lecture-based instruction and PowerPoint presentations. Classroom observations revealed limited student participation and insufficient opportunities for active knowledge construction, resulting in low levels of critical thinking, problem-solving, collaboration, and communication skills. Furthermore, students' academic achievement remains unsatisfactory, as evidenced by learning outcome data showing that 44.4% of students in one class and 33.3% in another failed to achieve the minimum competency standard score of 75 (KPBK Subject Teacher, 2024). These findings highlight the need for innovative learning resources that can promote active engagement and competency development (Vaesar et al., 2026).

One potential solution is the use of electronic modules (E-Modules), which provide flexible, interactive, and student-centered learning experiences (Desky et al., 2025). The integration of Flipbook technology enables E-Modules to present multimedia content—including text, images, videos, audio, and interactive features—in a more engaging and accessible format (Putri et al., 2022). Meanwhile, Project-Based Learning (PjBL) offers a pedagogical framework that emphasizes authentic projects, collaborative inquiry, and real-world problem solving, thereby facilitating deeper learning and the development of essential 21st-century competencies (Ermiyawati et al., 2025; Meriwati, 2025).

Previous studies have demonstrated the positive impact of PjBL-based E-Modules on student engagement and learning outcomes across various educational contexts (Ermawalis et al., 2025; Habib et al., 2026). Nevertheless, research focusing on the development of a Flipbook-based E-Module integrated with the PjBL model for Ship Outfit Construction in vocational education remains scarce. Moreover, existing studies predominantly emphasize cognitive achievement, with limited attention given to the simultaneous assessment of 4C skills—Critical Thinking, Communication, Collaboration, and Creativity—which are increasingly recognized as essential competencies for the Industry 4.0 workforce. (Agraini et al., 2026) Therefore, this study seeks to address this gap by developing, validating, and evaluating the effectiveness of a Flipbook-based PjBL E-Module using the ADDIE model to improve both learning outcomes and students' 4C skills (Risna et al., 2026).

Method

This research employed a Research and Development (R&D) approach Sugiyono (2020) using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). A mixed-method design combining quantitative and qualitative approaches was adopted. The quantitative component utilized a quasi-experimental design with a nonequivalent control group, while the qualitative component captured expert feedback and teacher/student responses.

Participants and Setting

The study was conducted at SMKN 5 Batam, specifically in the Ship Design and Construction Department, during the odd semester of the 2025/2026 academic year (July–December 2025). The target population comprised 90 students enrolled in the KPBK subject. Using purposive sampling, 40 students were selected and assigned to an experimental group ($n = 20$, using the Flipbook-based E-Module with PjBL) and a control group ($n = 20$, using conventional instruction). Both groups were matched based on academic GPA and pre-test performance to ensure comparability (Deviana et al., 2025; Putritama et al., 2026).

Development Procedure (ADDIE Model)

In the Analysis phase, needs analysis was conducted through literature review, classroom observation, and structured interviews with three KPBK teachers and 20 students. The results indicated a high demand for interactive digital learning materials integrated with the PjBL model, with average need scores of 4.28 (teachers) and 4.33 (students) on a five-point scale (Krisdiantoro et al., 2024; Zamil et al., 2025). In the Design phase, a comprehensive E-Module blueprint was developed consisting of six sections aligned with the PjBL syntax (Essential Question, Design a Plan, Create a Schedule, Monitor the Project, Assess the Outcome, and Evaluate the Experience), supported by 3D modelling visualizations and Augmented Reality. The developed Flipbook-based E-Module can be accessed through the website (<https://opitananda.my.id/>) or as shown in Figure 1.



Figure 1. Flipbook-Based E-Module Interface.

Development utilized Flip PDF Professional, Canva, and Microsoft Word. The E-Module incorporated technical specifications with cross-platform compatibility (online and offline access via computers and smartphones). Validation by experts in content, media, and pedagogy was conducted in this phase. Implementation involved pilot testing (small scale) followed by full-scale quasi-experimental deployment. Evaluation assessed validity, practicality, and effectiveness across all five ADDIE stages (Irfan et al., 2025; No et al., 2023).

Instruments

Research instruments included: (1) expert validation questionnaires involving subject-matter, media, and instructional design experts to assess the content validity and feasibility of the developed E-Module using Aiken’s V (Fiona et al., 2025; Nurpradana et al., 2017) (2) practicality questionnaires administered to teachers and students to evaluate usability and implementation feasibility; (3) pre-test and post-test instruments consisting of 60 multiple-choice items representing cognitive levels C1–C6 based on the revised Bloom’s Taxonomy (Anderson & Krathwohl 2001); and (4) 4C skills assessment sheets comprising 50 indicators measuring critical thinking, communication, collaboration, and creativity competencies.

Data Analysis

Content validity was assessed using Aiken’s V coefficient, which remains widely employed for expert judgment validation studies. Reliability was evaluated

using Cronbach’s Alpha, with values greater than 0.70 indicating satisfactory internal consistency. Practicality was measured using the Respondent Achievement Level (TCR) formula: $TCR = (\text{mean score} / \text{ideal score}) \times 100\%$. The effectiveness of the developed E-Module was analyzed using Paired Samples t-Test and Independent Samples t-Test, followed by Cohen’s d effect size analysis to determine the magnitude of treatment effects (Cohen, 1988). Furthermore, Multivariate Analysis of Variance (MANOVA) was employed to examine simultaneous differences in cognitive learning outcomes and 4C skills between the experimental and control groups. All statistical analyses were conducted using SPSS and SmartPLS 4 with a significance level of $\alpha = 0.05$.

Result and Discussion

Development and Validity of the Flipbook-based E-Module with PjBL

The needs analysis revealed that all six assessed dimensions (demographic characteristics, learning style preferences, content needs, technology preferences, PjBL familiarity, and 4C skills development needs) were rated highly by both teachers and students (Table 1). The 4C Skills Development dimension received the highest scores (4.55 from teachers; 4.53 from students), confirming the pedagogical urgency of integrating 21st-century competency development into the KPKB subject.

Table 1. Needs Analysis Results for E-Module Development

Dimension	Code	Teacher Score	Student Score
Demographic & Academic Characteristics	KDA	4.37	4.16
Learning Style Preferences	PGB	4.04	4.21
Content & Material Needs	KKM	4.12	4.47
Technology & Multimedia Preferences	PTM	4.33	4.36
PjBL Familiarity & Expectations	FEPjBL	4.29	4.25
4C Skills Development Needs	KPK-4C	4.55	4.53
Overall Average		4.28	4.33

Source: Primary Data (2025)

The design phase produced a structured E-Module with 3 learning modules following the PjBL syntax, enriched with 3D modelling visualizations (including Augmented Reality output of Generator Seating) and interactive multimedia elements. Expert validation confirmed the E-Module's validity across all dimensions, with Aiken's V values ranging from 0.68 to 0.92 (all ≥ 0.60). Cronbach's Alpha values for the validation

instrument ranged from 0.829 to 0.951, indicating high to very high reliability. The test instrument validity showed Aiken's V values between 0.68 (Language Feasibility, Valid) and 0.92 (Ease of Use, Very Valid), with all Cronbach's Alpha values exceeding 0.80. Similarly, all 50 items in the 4C skills assessment sheet obtained valid to very valid ratings (Aiken's V = 0.625–0.875) with Cronbach's Alpha values of 0.806–0.921.

Practicality of the Flipbook-based E-Module

Teacher practicality assessment (n = 3) across five dimensions yielded an overall TCR of 91.11% (mean = 4.56/5.00), categorized as Very Practical (Table 2). All five dimensions—Ease of Implementation (92.22%),

Media Effectiveness (90.00%), Classroom Management (90.00%), Usage Flexibility (92.22%), and Impact on Teaching (91.11%)—were classified as Very Practical. These results are also presented in Figure 1.

Table 2. Teacher Practicality Assessment Results

Dimension	Mean	TCR (%)	Category
Ease of Implementation	4.67	92.22	Very Practical
Media Effectiveness	4.56	90.00	Very Practical
Classroom Management	4.61	90.00	Very Practical
Usage Flexibility	4.72	92.22	Very Practical
Impact on Teaching	4.61	91.11	Very Practical
Overall	4.63	91.11	Very Practical

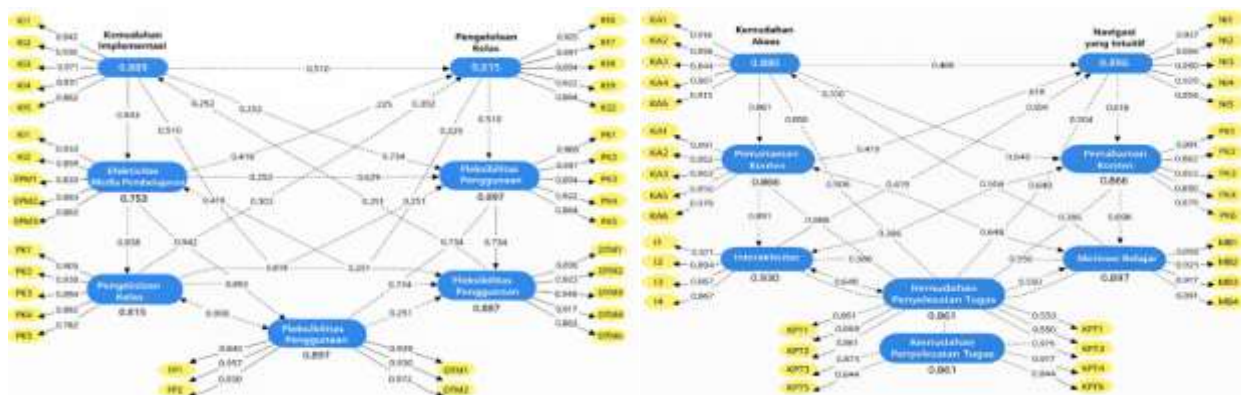


Figure 2. Practicality Graphical Output in SmartPLS 4

Student practicality assessment (n = 20) across six dimensions yielded an overall TCR of 91.18% (mean = 4.59/5.00), also categorized as Very Practical. The Interactivity dimension received the highest rating (TCR = 93.11%), followed by Intuitive Navigation (92.22%) and Learning Motivation (92.22%). These findings align with previous research (Irawan & Delianti, 2025; Lubis et al., 2024)) confirming that well-designed flipbook E-Modules are positively received by both teachers and students due to their accessibility, visual appeal, and flexibility of use.

Effectiveness of the Flipbook-based E-Module

Prior to effectiveness testing, normality (Kolmogorov-Smirnov: p > 0.05) and homogeneity (Levene's test: p > 0.05) assumptions were confirmed for all variables, validating the use of parametric tests.

The Paired Samples T-Test revealed significant within-group improvements in both the experimental and control groups (p < 0.001). The experimental group improved by 28.25 points (from 54.95 to 79.43), while the control group improved by 20.70 points. The between-group difference in improvement (7.55 points) indicates the additional benefit of the PjBL-based E-Module.

Table 3. Summary of Effectiveness Test Results

Test	Variable	Statistic	Result	Conclusion
Paired T-Test	Post-test (Experiment)	t = -107.023, df = 19	p < 0.001	Significant
Paired T-Test	Post-test (Control)	t = -118.044, df = 19	p < 0.001	Significant
Independent T-Test	Post-test Score	t = -6.429, df = 38	p < 0.001	Significant
Independent T-Test	4C Skills Score	t = -4.250, df = 38	p < 0.001	Significant
Effect Size	Post-test (Cohen's d)	2.87 (95% CI: 1.99–3.75)	Large	Very Large Effect
Effect Size	4C Skills (Cohen's d)	1.42 (95% CI: 0.84–2.00)	Large	Very Large Effect
MANOVA	Combined DVs	F = 97.203, df = 2; 37	p < 0.001	Significant

Source: SPSS Analysis Output (2025)

The Independent Samples T-Test confirmed significantly higher post-test scores in the experimental group (84.20 vs. 74.45, difference = 9.75 points; $t = -6.429$, $p < 0.001$) and higher 4C skills scores (85.60 vs. 74.35, difference = 11.25 points; $t = -4.250$, $p < 0.001$). Cohen's d values of 2.87 for learning outcomes and 1.42 for 4C skills indicate very large practical effects, substantially exceeding Cohen's (1988) threshold for large effects ($d \geq 0.80$). The MANOVA results confirmed simultaneous significant differences across all dependent variables (Pillai's Trace = 0.842, Wilks' Lambda = 0.158, $F = 97.203$, $df = 2; 37$, $p < 0.001$), demonstrating the E-Module's multidimensional effectiveness.

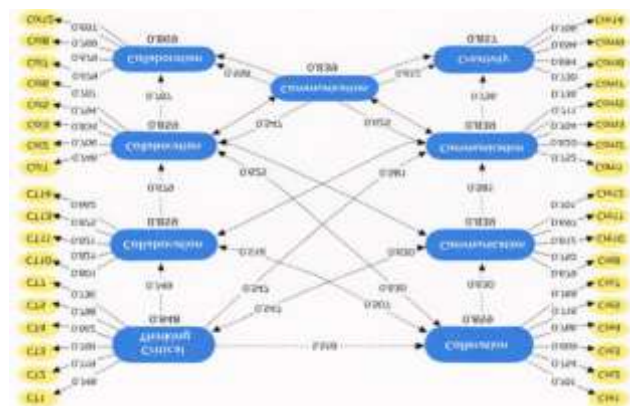


Figure 3. Validity Results of the 4C Skills Test Instrument Using SmartPLS 4

These findings are consistent with the constructivist learning theory (Taali et al., 2024), which posits that meaningful learning occurs through active knowledge construction in authentic contexts. The integration of PjBL syntax with interactive multimedia—including 3D modelling simulations and Augmented Reality of Generator Seating designs—provided students with authentic learning experiences directly connected to the ship construction industry (Sudianti et al., 2025). This contextual authenticity is a key factor distinguishing this study from previous e-module research, which often focused narrowly on cognitive outcomes without measuring the holistic development of 21st-century competencies (Habib et al., 2025).

The high practicality scores align with findings by Irawan & Delianti (2025); Mardiana et al. (2026), who demonstrated that well-designed digital modules significantly enhance student and teacher engagement when they offer cross-platform accessibility, intuitive navigation, and contextually relevant content. The very large effect sizes observed in this study surpass those reported in comparable research (Sudira et al., 2022), potentially attributable to the unique integration of industry-specific 3D modelling content with

Augmented Reality technology and the comprehensive PjBL implementation across all six syntactic stages.

Conclusion

This study demonstrates that the Flipbook-based E-Module integrated with the Project-Based Learning (PjBL) model is a valid, practical, and effective learning resource for improving students' learning achievement and 4C skills in the Ship Outfit Construction (3D Modelling) subject. The effectiveness of the developed module was evidenced by a large effect size (Cohen's $d = 2.87$) and significant improvements in students' competencies. The findings highlight the potential of combining interactive digital learning media with project-based learning to support more engaging, student-centered, and competency-oriented vocational education. The novelty of this study lies in the integration of Flipbook technology and the PjBL model within a maritime vocational education context while simultaneously evaluating cognitive learning outcomes and 21st-century skills. However, the study was limited to a relatively small sample of 40 students from a single vocational school and a short implementation period, which may limit the generalizability of the findings. Therefore, future research should involve larger and more diverse samples, examine long-term impacts on work readiness and employability, and explore the integration of emerging technologies such as Augmented Reality and Artificial Intelligence to further enhance vocational learning.

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Author Contributions

Conceptualization, O.T.; methodology, O.T.; software, O.T.; validation, O.T.; formal analysis, O.T.; investigation, O.T.; resources, O.T.; data curation, O.T.; writing—original draft preparation, O.T.; writing—review and editing, O.T.; visualization, O.T.; supervision, W.P.; project administration, O.T. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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