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Developing an Integrated Project-Based Learning Application to Enhance Learning Practicals in Vocational Schools

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Abstract: The implementation of a digital PjBL-based system significantly assists teachers in documenting practical learning and improving accountability for the learning process. The use of a digital PjBL management system not only increases student engagement but also significantly improves the quality of automotive engineering practice through progress tracking and real-time feedback.This study aims to design and develop a project-based learning (PjBL) management system suitable for automotive practice in vocational high schools and to assess its feasibility and effectiveness in enhancing student engagement and learning outcomes. The research employed a Research and Development (R&D) method adapted from the Borg & Gall and Sugiyono models. The developed web-based system features project management, evidence uploads, rubric-based assessments, discussion forums, and student progress monitoring. Validation was conducted by media experts and vocational practitioners, while limited trials involved 30 students from Grade XI of the Light Vehicle Engineering program. Results showed the system was highly feasible with an average score of 85.5%. The system improved student engagement scores from 3.04 to 4.3 and learning outcomes from 72.3 to 85.1. These findings confirm that a digital PjBL system effectively enhances practical learning in vocational education.

Keywords: **A**utomotive practice; Digital system; Learning outcomes; Project-based learning; Student engagement; Vocational high school

Introduction

Vocational High Schools (SMK) play a strategic role in producing a ready-to-use and skilled workforce, in line with industrial and technological developments. Expertise programs such as Automotive Engineering require students to master practical skills such as fault diagnosis, vehicle system maintenance, and the use of modern workshop tools. For optimal practical learning, an approach is needed that trains students to be active, responsible, and capable of solving real-world problems. One approach that aligns with the characteristics of practical learning in vocational high schools is Project-Based Learning (PjBL). PjBL places real-life projects at the center of learning, where students learn by working, observing, and reflecting on the process (Guo et al., 2020; Novalia et al., 2025). In the context of automotive practice, the use of PjBL-based modules for light vehicle engine maintenance has been shown to improve students' work skills and strengthen their readiness for the industrial world. This model not only improves learning outcomes but also encourages the development of soft skills such as collaboration, creativity, and independence (Mazrur et al., 2024; Skrbinjek et al., 2024).

Research by Almulla (2020) and Sukackė et al. (2022), shows that the application of Project-Based Learning (PjBL) in light vehicle engineering lessons significantly improves student learning activities and work outcomes (Apriadi et al., 2020). Similarly, Lestari

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et al. (2024) and Wahdaniyah et al. (2023), reports that the PjBL approach integrated with STEM in automotive practice is able to strengthen students' critical thinking skills and work documentation. Vocational High Schools (SMK), especially Automotive Engineering programs, play a crucial role in producing skilled workers. Effective practical learning requires an approach that encourages student activeness, responsibility, and problem-solving abilities. Project-Based Learning (PjBL) is an appropriate approach, as it places real-life projects at the core of learning, proven to improve students' work skills and soft skills in automotive practice. Many studies support that PjBL improves students' learning outcomes, activities, and critical thinking (Tafakur et al., 2023; Zhang & Ma, 2023). However, in practice, the implementation of PjBL still faces obstacles, particularly in documentation, assessment, and tracking of student progress (Putri et al., 2024; Sagita et al., 2023). Teachers often use inefficient manual methods, while students lack clear feedback on the progress of their work (Gan et al., 2021; Singun, 2025).

Observations at the Nias Regional Government Private Vocational High School (SMK Pembda) confirmed teachers' difficulties in systematically managing projects and the lack of information provided to students regarding their progress. To address these issues, a web-based Project-Based Learning (PjBL) application (VocaTeach.com) was developed using PHP and MySQL. This application is designed to support project-based learning in vocational high schools with features such as (Suparmi et al., 2024; Roemintoyo & Budiarto, 2023). Project management: Teachers can create and manage practical projects; Upload evidence of work: Students can upload photos of their practical work; Assessment and feedback: Teachers can provide rubric-based assessments and written feedback (English et al., 2022; Vasileiadou & Karadimitriou, 2021); Progress monitoring: All progress is recorded and monitored; Discussion forums: A means for reflection and Q&A. Studies have shown that a digital Project-Based Learning (PjBL) system like this can increase student engagement, productivity, motivation, and higher-order thinking skills in automotive learning, while also enabling teachers to become mentors and evaluators based on real-world evidence (Sánchez-García & Reyes-de-Cózar, 2025).

Based on the above background, this research was conducted with the following objectives: Designing and developing a project-based learning management system suitable for automotive engineering practicals in vocational high schools; Assessing the system's feasibility based on aspects of functionality, usability, and usability according to teachers and students; Analyze the influence of system use on student engagement and practical learning outcomes.

Method

Research Type and Approach

This research is a research and development (R&D) study with the goal of creating a Project-Based Learning (PjBL) application for automotive engineering practice in vocational high schools. The development model used is a modification of Borg & Gall's, simplified by Ezezika & Johnston (2023), encompassing six stages: Potential and problems: Identifying needs in the field; Data collection: Literature review and observation; Product design: System design; Design validation: Expert assessment; Limited trials: Classroom implementation; Product revision: Improvements based on feedback. This R&D approach was chosen because of its effectiveness in developing digital learning media and systems, which can improve efficiency, transparency, and competency achievement in vocational education.

Research Location and Time

The research was conducted at SMK Swasta Pembda Nias, Gunungsitoli, North Sumatra, a vocational school with an Automotive Light Vehicle Engineering program. This location was chosen because it had active workshop facilities, teachers accustomed to conventional PjBL but not yet using a digital system, and a school environment open to technological innovation. The research period lasted one semester (January-June 2025), encompassing needs identification, system development, expert validation, limited trials, and analysis of results.

Research Subjects and Objects

The research object was a project-based learning management system (PjBL Application) for automotive engineering. This system includes features for documenting work steps, assigning projects, uploading work evidence, rubric-based assessments, and digitally tracking student progress. The research subjects were selected through purposive sampling, consisting of: One productive Automotive Light Vehicle Engineering teacher; 30 11th-grade Automotive Light Vehicle Engineering students directly involved in workshop practices. This selection ensured relevant input from direct users of the system.

Development Procedure

The development followed the six main stages of Sugiyono's R&D model: Needs Analysis: Identifying teacher difficulties in monitoring and assessing practice, as well as the lack of feedback for students through

observation and interviews; Application System Design: Designing a web application (PHP, MySQL) with a separate dashboard, project management, evidence upload, rubric assessment, discussion forum, and progress monitoring; Product Development: Prototyping basic functionality (file upload, assessment, progress tracking) and testing internal stability; Expert Validation: The prototype was validated by two experts (an ICT lecturer and a senior automotive teacher) using a media feasibility instrument; Limited Trial: The system was tested by 30 students in real practice at a workshop. Data were collected through questionnaires, interviews, and interaction documentation; Product Revision: Technical and design improvements based on input from expert validation and limited trials.

Data Collection Techniques

Data was collected through various techniques: Observation: Observing student activities before and after using the application; Interviews: Exploring teacher and student perceptions; Expert Validation Questionnaire: Assessing system feasibility (4-point Likert scale); Student Engagement Questionnaire: Measuring participation, reflection, collaboration, and independence; Learning Outcome Test: Measuring practice improvement through pre- and post-tests; Documentation: Screenshots, assignment reports, and system progress data; PjBL Application System Log: Automatically recording user activity.

Application System Design

The PjBL application is designed with a client-server architecture (users access the PHP and MySQL servers through a browser). Context diagrams, use case diagrams, and DFDs (Level 0 and Level 1 for assessment) are used to illustrate the system's relationships with external entities and process flows.

Implementation and Technology

The application was developed using PHP (without a framework), MySQL as the database, and Bootstrap for the interface.

System Validation and Trial

Validation was conducted involving teachers (testing assignment input, grading, tracking) and students (testing project access, uploading evidence, viewing feedback). Feedback was collected through questionnaires and interviews.

Research Instruments

The instruments used included: Practical Observation Sheets: To record student activities directly; Interview Guidelines: To explore teacher and student perceptions; Expert Validation Questionnaire: To assess system feasibility by experts; Student Engagement Questionnaire: To measure student participation and interaction; Automotive Practical Assessment Rubric: To assess the technical quality, procedures, safety, and documentation of student work; PjBL Application System Log: To automatically record user activity.

Data Analysis Techniques

Qualitative data (interviews, observations) were analyzed descriptively thematically. Quantitative data were analyzed using descriptive statistics (mean, percentage), gain score analysis (difference between pre-test and post-test), and interpretation of validation results (categories ≥ 81% are very feasible).

Success Indicators

A product is considered successful if it meets the following criteria: Expert validation score ≥ 81% (very feasible); Average student engagement score increases; Post-test scores are higher than pre-test scores; Teachers report that the application facilitates assessment and documentation; Students feel supported and motivated.

Results and Discussion

Application Development Process

The application development was carried out following the R&D (Research and Development) model stages as described in Chapter III. The resulting product is a web-based PjBL Management Application to support automotive practical learning in vocational high schools. The application's main features include: Project management and work steps by teachers; Uploading practical evidence in the form of photos and reports by students; Objective and documented rubric-based assessments; Discussion forums for collaboration and reflection; and real-time monitoring of project progress. The application was developed using PHP, MySQL, HTML/CSS, and Bootstrap. The database is relational and connected through the entities users, projects, steps, task_evidence, and evaluation_logs. The system interface is designed to be responsive for access on desktop and mobile devices.

Expert Validation Results

Validation was conducted by three experts: a Computer Science Lecturer (digital media expert); the Principal of a Private Vocational High School, Pembda Nias (Institutional Head); and a Computer and Network Engineering Teacher (Field Practitioner). The assessment covered three aspects: appearance and navigation, feature functionality, and system usability. Each aspect was given a maximum score of 20 points.

Validation results indicate that the application meets the eligibility standards for use in vocational high

schools. The highest score was given by the principal (91.7%), who deemed the system highly relevant to the institution's needs. The Computer Science lecturer assessed the system's strengths in interface design and functional stability. The Computer and Network Engineering (TKJ) teacher noted that the system was quite easy to use but suggested strengthening account security. The average score from the three validators reached 85.5%, indicating that the application is generally highly suitable for use as a PjBL practice management system (Nurmaliah et al., 2021).

Table 1. Expert validation results

Validator	Appearance (20)	Functionality (20)	Functionality (20)	Total Score	Percentage (%)	Category
Computer Science Lecturer	18	17	16	51	85	Very Worthy
Principal of a Private Vocational School under the Nias Regional Government	19	18	18	55	91.70	Very Worthy
Computer and Network Engineering Teacher	17	16	15	48	80	Worthy
Average	18	17	16.30	51.30	85.50	Very Worthy

Limited Trial Results

The trial was conducted for two weeks by 30 11th-grade Automotive Engineering students on a project themed "Ignition System Maintenance." Evaluation included student engagement and learning outcomes.

Student Engagement (Questionnaire Data)

Table 2. Level of student engagement (questionnaire)

Indicators	Before	After	Improvement
Participation	3.10	4.40	+1.30
Collaboration	3	4.20	+1.20
Self-Reflection	2.90	4.10	+1.20
Responsibility	3.20	4.50	+1.30
Initiative	3	4.30	+1.30
Average	3.04	4.30	+1.26

Before using the application, the average student engagement score was 3.04, indicating a moderate level of engagement. After using the PjBL application, the average increased to 4.3. The responsibility indicator experienced the highest increase, from 3.2 to 4.5 (+1.3). This improvement reflects that the system helps students understand the project workflow, manage their time, and complete assignments more independently and systematically. Self-reflection also increased significantly (+1.2), indicating that the digital documentation and feedback features in the system foster awareness of students' work processes.

Student Learning Outcomes (Formative Test)

Table 3. Impact of the application on student understanding

Test	Average	Standard Deviation
Pre-test	72.30	6.40
Post-test	85.10	5.80
Gain	+12.80	-

The average student pre-test score of 72.30 reflected a sufficient but not yet optimal level of initial understanding. After using the PjBL application, the average score increased to 85.1, with a score gain of 12.8 points. This improvement indicates a strengthening of technical and procedural understanding through documented project-based learning. The decrease in the standard deviation from 6.40 to 5.80 indicates that student learning outcomes not only improved but also became more equitable, making this application effective for students with diverse abilities.

Student Practice Observation Results

Observations were conducted by teachers throughout the practicum process. Aspects observed included engagement, independence, tool use, collaboration, discipline, and self-reflection. Observations of 30 students revealed that most students scored between 3.0 and 3.6 on six key indicators. The highest scores were achieved on the "tool use" and "engagement" indicators, indicating that students actively participated in the project and were accustomed to using workshop equipment correctly. Meanwhile, self-reflection and discipline scores varied, indicating the need for further guidance in developing professional work attitudes (Hirschi & Koen, 2021). Observation notes also reinforce the finding that students who actively engage in the digital system (uploading work evidence, interacting in forums, and reading feedback) tend to demonstrate better field performance. (The table is presented separately as an appendix to the observation data).

Discussion

The results of the study indicate that the PjBL application (Chintya et al., 2023; Aprinaldi et al., 2023): Is suitable for use (validation score of 85.5%) based on assessments by three experts representing the technical,

institutional, and pedagogical dimensions; Significantly increases student engagement (from 3.04 to 4.30) based on both the questionnaire and field observations; Improves learning outcomes with a score gain of 12.8 points and a narrowing standard deviation (Berhitu et al., 2020), indicating equitable improvement (Dumont & Ready, 2020; Tate & Warschauer, 2022; Krans et al., 2022). These findings are consistent with previous studies such as Chiang & Lee (Snyder, 2019), Kovács (2025), and Tennant & Ross-Hellauer (2020). The digital system encourages students to be more reflective, independent, and documented in their practice (Weerakoon, 2023; Awidi & Klutsey, 2024; Yaseen et al., 2025). Furthermore, it assists teachers in monitoring progress and providing fair assessments based on concrete evidence (Pfingsthorn & Weltgen, 2022; Krans et al., 2022; Omar & Nehdi, 2018). Therefore, this application is recommended for wider implementation in vocational high schools with curriculum adjustments and user training (Lin et al., 2024; Haleem et al., 2022; Long et al., 2025).

Conclusion

Based on the development, validation, and trials, it can be concluded that: Project-Based Learning (PjBL) Application System Successfully Developed: A web application for Project-Based Learning (PjBL) management in vocational high school automotive engineering practice has been successfully created. This application offers complete features for project management, task distribution, uploading practice evidence, rubric-based assessment, discussion forums, and real-time monitoring of student progress, meeting the needs of digital documentation and evaluation; Highly Feasible System: This application was rated highly feasible by three experts (vocational teacher, media expert, principal) with an average feasibility score of 85.5%. The system's functionality, interface, and usability aspects received very good ratings, supporting the efficiency and accountability of vocational learning; Improved Student Engagement and Learning Outcomes: A limited trial of 30 students showed a significant increase in learning engagement (average score increased from 3.04 to 4.3) and learning outcomes (average pre-test score of 72.3 to post-test 85.1, with a score gain of 12.8 points). This proves that the application contributes to more structured, documented, and reflective practical learning, helping vocational schools face the challenges of digitalization and the industrial revolution 4.0.

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