

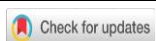


# Development of a Project-Based Learning Management System to Improve VLAN Configuration Competence (Case Study of Class XI TKJ Students at SMKN 1 Surabaya)

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## ABSTRACT

**Objective:** This study aims to develop a Moodle-based Learning Management System (LMS) integrated with a Project-Based Learning (PjBL) approach and to examine its effectiveness in improving Virtual Local Area Network (VLAN) configuration competencies among eleventh-grade students of the Computer and Network Engineering (CNE) program at SMKN 1 Surabaya. **Method:** The research employed a Research and Development (R&D) method using the ADDIE model. The subjects were an experimental and a control class. Data were collected through expert validation, cognitive tests, and psychomotor performance assessments. Data analysis was conducted using the Mann-Whitney U test and the independent-samples t-test based on the data distribution. **Results:** The developed LMS demonstrated very high feasibility, with a media validation score of 93.3%. Statistical analysis revealed significant differences in both cognitive and psychomotor competencies between the experimental and control groups ( $p < 0.05$ ). These findings indicate that integrating a Moodle-based LMS with the PjBL approach effectively enhances students' VLAN configuration competencies in vocational education. **Novelty:** The novelty of this study lies in the explicit integration of Project-Based Learning syntax into the design and functionality of a Moodle-based LMS for VLAN configuration practice, enabling a balanced development of theoretical understanding and psychomotor skills within a vocational, project-oriented learning context.

## INTRODUCTION

The development of information and communication technology has driven significant transformations in educational practices, particularly in vocational education, which demands a strong link between learning and workplace needs (Deaconu et al., 2018; Khan & Markauskaite, 2018). Vocational High Schools (SMKs) are required to produce graduates who not only understand theoretical concepts but also possess measurable practical competencies aligned with industry standards. However, various studies show that conventional lecture and demonstration-based learning still dominates vocational classes, resulting in low conceptual understanding and application skills for students, particularly in technical and procedural material such as Virtual Local Area Network (VLAN) configuration (Maritsa et al., 2021; Ayu, 2024).

The main problems that frequently arise in learning network infrastructure administration are limited time for practical work, a lack of interactive media, and low student engagement in the learning process (Mutohhari et al., 2021). These conditions make it difficult for students to connect networking concepts with real-world applications. Previous research reported that more than half of vocational high school students are unable to comprehensively understand networking material when learning relies solely on conventional methods without the support of structured digital media (Dila & Anggraeni, 2023). This situation indicates a gap between competency-based learning objectives and classroom learning practices.

Several recent studies recommend using a Learning Management System (LMS) to increase flexibility, interactivity, and learning effectiveness. The Moodle-based LMS, an open-source platform, is considered capable of facilitating integrated online and offline learning and supporting independent and collaborative learning activities (Chaeruman, 2015; Rizal et al., 2019). On the other hand, the Project-Based Learning (PjBL) approach has proven effective in improving students' higher-order thinking skills, learning independence, and problem-solving abilities through the completion of authentic projects (Sudianto et al., 2019; Lestari & Yuwono, 2023). However, most research still examines LMS and PjBL separately, without integration specifically aimed at improving technical networking competency.

Based on this research gap, this study proposes the development of a Moodle-based Learning Management System systematically integrated with the Project-Based Learning approach for VLAN configuration learning in vocational high schools. The developed LMS not only serves as a material repository but is also designed to accommodate the entire PjBL syntax, from problem orientation, problem formulation, and analysis to project planning, implementation, evaluation, and reflection. This integration is expected to create a contextual learning ecosystem, encourage active student engagement, and simultaneously improve the achievement of cognitive and psychomotor competencies.

The novelty of this research lies in the design of the Moodle LMS, specifically tailored to the characteristics of vocational learning and VLAN configuration competency. Its effectiveness was validated and tested through a comparison of learning outcomes between project-based learning and conventional learning. Unlike previous research, this study positions the VLAN configuration project as the core of the learning process rather than merely a supporting activity, thereby making practical and empirical contributions to the development of digital learning models in vocational schools.

Thus, the purpose of this study is to develop and test the effectiveness of a Moodle-based LMS with a Project-Based Learning approach in improving VLAN configuration competency of vocational high school students. Theoretically, this study is expected to enrich research on the integration of LMS and PjBL in vocational education. In practice, the research results serve as a reference for teachers, schools, and policymakers in designing technology-based learning that is more contextually relevant, adaptive, and aligned with industry needs.

## **RESEARCH METHOD**

### ***Research design***

This study employed a Research and Development (R&D) design with a quantitative approach, aiming to produce learning products while empirically testing their effectiveness. The development model applied was ADDIE (Analyze, Design, Develop, Implement, and Evaluate) because it provides a systematic, iterative process for designing, developing, and evaluating technology-based learning media. ADDIE was selected based on its ability to integrate needs analysis, instructional design, expert validation, and evaluation of learning effectiveness in a structured manner, making it suitable for developing a Moodle-based Learning Management System (LMS) in the context of vocational education.

In the implementation phase, this study employed a quasi-experimental posttest-only control-group design. This design was chosen because classroom conditions at the

school did not permit full subject randomization, but still allowed for objective comparisons between the experimental and control groups to assess the effect of implementing a Project-Based Learning (PjBL)-based LMS on students' VLAN configuration competencies.

### *Research subjects and locations*

The research was conducted at SMK Negeri 1 Surabaya in the Network Infrastructure Administration subject. The subjects were two eleventh-grade TKJ (Computer and Network Engineering) classes with relatively similar academic characteristics. One class was designated as the experimental group, receiving learning using the Moodle LMS with a PjBL approach. In contrast, the other class served as the control group, receiving conventional learning without an LMS.

### *Data analysis techniques*

Data analysis was conducted in stages to ensure the validity and reliability of the research results. Validation data were analyzed using descriptive statistics, expressed as percentages of appropriateness, to determine product validity categories. Student learning outcome data were analyzed through the following stages.

First, a normality test was conducted using the Shapiro-Wilk test to determine data distribution. Second, a homogeneity-of-variance test was conducted using the Levene test to assess whether variances were equal across groups. Third, hypothesis testing was conducted by adjusting the results of the prerequisite tests. If the data were not normally distributed, the non-parametric Mann-Whitney U test was used to compare learning outcomes between the experimental and control groups. Conversely, if the data met parametric assumptions, a two-sample independent t-test was used.

The results of the statistical analysis were then interpreted based on the significance value ( $\alpha = 0.05$ ). Conclusions were drawn by comparing the significance value against the hypothesis testing criteria to determine whether there were differences and improvements in student competency resulting from the implementation of the Project-Based Learning LMS.

## **RESULTS AND DISCUSSION**

### *Results*

#### *Learning management system development results*

The product of this research is a Moodle-based Learning Management System (LMS) designed to support VLAN configuration learning using a Project-Based Learning (PjBL) approach. The LMS was developed based on the ADDIE stages and includes key features that reflect the PjBL syntax, including problem orientation, problem formulation and analysis, project scheduling, implementation monitoring, project results collection, presentation, and evaluation and reflection.

Expert validation results indicate that the developed LMS is highly suitable for use in learning. Validation includes aspects of media, learning tools (RPP/Teaching Modules), materials, and evaluation instruments. A summary of the validation results is presented in Table 1.

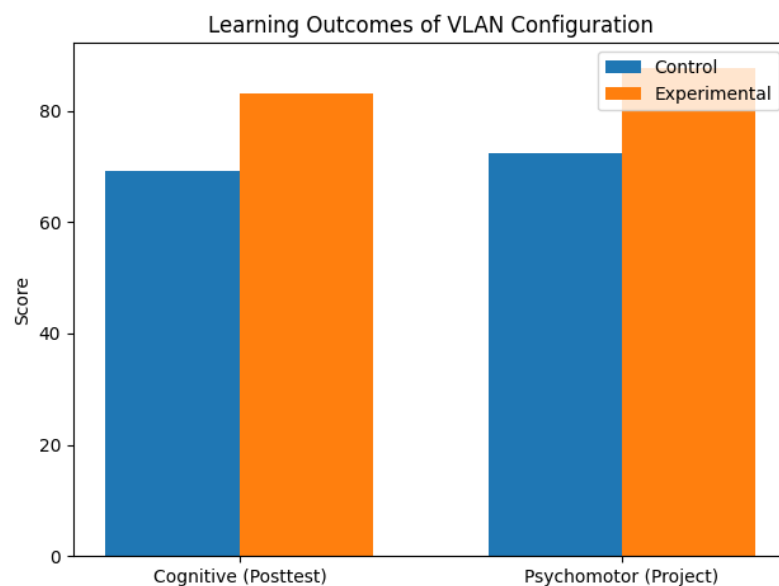
**Table 1.** Validation recapitulation results

No	Validation Assessment	Validity	Information
1	Media	93.3%	Very Worthy

No	Validation Assessment	Validity	Information
2	Lesson plan/teaching module	81.71%	Very Worthy
3	Material	94.5%	Very Worthy
4	Posttest questions	95%	Very Worthy

### *Learning implementation results*

The LMS was implemented in the experimental group, while the control group underwent conventional learning. Student learning outcomes were measured using cognitive tests and psychomotor assessments based on a VLAN configuration project. The average learning outcomes for both groups are presented in Figure 1.



**Figure 1.** Student learning outcomes

Figure 1 shows that the experimental group achieved higher average scores than the control group in both assessment aspects. This improvement indicates that integrating project-based learning into the LMS can optimally promote both conceptual understanding and practical skills among students. These results support previous findings that PjBL is effective in improving cognitive and psychomotor learning outcomes in vocational education (Rismawati et al., 2019 ; Sudianto et al., 2019).

### *Statistical analysis results*

To ensure that the differences in learning outcomes were statistically significant, normality and homogeneity tests were conducted, and the hypothesis was tested. The results of the normality test indicated that the data were not normally distributed; therefore, the Mann-Whitney U test was used to test the hypothesis.

The Mann-Whitney U test results for the cognitive and psychomotor aspects showed a p-value of  $< 0.05$ , indicating a significant difference between the experimental and control groups. Therefore, the null hypothesis ( $H_0$ ) was rejected, and the alternative hypothesis ( $H_1$ ) was accepted. These findings confirm that using a Moodle-based LMS with a PjBL approach significantly improves students' VLAN configuration competency.

## *Discussion*

The results of this study demonstrate that integrating a Moodle-based LMS with a Project-Based Learning approach not only serves as a learning support medium but also as a primary tool for building contextual, meaningful learning experiences. Project-Based Learning (PjBL) allows students to directly engage in solving real-world problems through VLAN configuration projects, thereby fostering critical thinking, collaboration, and the practical application of concepts.

The improvement in learning outcomes in the experimental group demonstrates that LMS-supported project-based learning can overcome the limitations of conventional learning, such as limited practice time and low student interaction. This finding aligns with constructivist theory, which emphasizes that knowledge is actively constructed through direct learning experiences and reflection (Lestari & Yuwono, 2023). Furthermore, this study's results strengthen empirical evidence that the use of learning technologies tailored to vocational characteristics can improve students' readiness to meet workforce demands.

## CONCLUSION

**Fundamental Finding:** Penelitian ini menyimpulkan bahwa pengembangan Learning Management System (LMS) berbasis Moodle yang diintegrasikan dengan pendekatan Project-Based Learning (PjBL) merupakan strategi pembelajaran yang efektif untuk meningkatkan kompetensi konfigurasi VLAN pada siswa Sekolah Menengah Kejuruan. LMS yang dikembangkan tidak hanya berfungsi sebagai media distribusi materi, tetapi menjadi lingkungan belajar terpadu yang mengarahkan siswa pada proses pemecahan masalah berbasis proyek secara sistematis. Integrasi sintaks PjBL ke dalam fitur LMS membuat pembelajaran lebih kontekstual, partisipatif, dan sesuai dengan karakteristik pendidikan vokasi yang menekankan keterampilan praktik serta penerapan langsung.

**Implication:** Temuan menunjukkan bahwa LMS berbasis proyek mampu menjembatani kesenjangan antara penguasaan konsep teoretis dan keterampilan psikomotorik siswa. Proyek nyata mendorong siswa membangun pengetahuan secara aktif, berkolaborasi dalam kelompok, serta melakukan refleksi berkelanjutan terhadap hasil kerja. Secara praktis, hasil penelitian ini memberi implikasi bagi sekolah dan pendidik dalam merancang pembelajaran digital yang efektif dan berkelanjutan, termasuk sebagai model alternatif atau pelengkap pembelajaran tatap muka dalam konteks pembelajaran hybrid di SMK.

**Limitation:** Penelitian ini berfokus pada peningkatan kompetensi konfigurasi VLAN pada konteks SMK dan pada indikator hasil belajar kognitif serta psikomotorik, sehingga generalisasi ke kompetensi kejuruan lain atau jenjang berbeda masih terbatas. Selain itu, variabel dampak lain seperti motivasi belajar, kemampuan pemecahan masalah, dan kesiapan kerja belum dianalisis secara mendalam.

**Future Research:** Penelitian lanjutan dapat memperluas penerapan LMS berbasis PjBL untuk kompetensi kejuruan lain, baik pada bidang jaringan komputer maupun bidang vokasi lain yang berbasis praktik. Pengembangan selanjutnya juga dapat diarahkan pada integrasi fitur learning analytics, penilaian adaptif, serta pemanfaatan data aktivitas siswa untuk mendukung pembelajaran yang lebih personal. Studi berikutnya juga dapat menguji dampak LMS berbasis proyek terhadap variabel lain seperti motivasi, problem-solving, kolaborasi, dan kesiapan kerja, termasuk dalam skala implementasi yang lebih luas dan jangka panjang.

## AUTHOR CONTRIBUTIONS

**Galang Satria Pratama Putra** conducted the study, including the development of the Moodle-based LMS, data collection, statistical analysis, and manuscript preparation. **Ekohariadi** provided academic supervision and validated the research instruments and media. **Cahyo Febri Wijaksono** reviewed and revised the manuscript critically and approved the final version for submission. All authors have read and approved the final manuscript.

## CONFLICT OF INTEREST STATEMENT

The authors confirm that there are no conflicts of interest, either financial or personal, that may have influenced the content or outcome of this study.

## ETHICAL COMPLIANCE STATEMENT

This manuscript complies with research and publication ethics. The authors affirm that the work is original, conducted with academic integrity, and free from any unethical practices, including plagiarism.

## STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors acknowledge the use of digital tools, including AI-based technologies, to support the research and writing processes of this article. Specifically, ChatGPT (OpenAI) was used for language refinement, improving manuscript structure, and assisting with summarization and paraphrasing of non-copyrighted content. Microsoft Excel was used for data processing and visualization. All AI-assisted outputs were critically reviewed, verified, and revised by the authors to ensure academic rigor, originality, and compliance with ethical standards. The authors take full responsibility for the content, interpretations, and conclusions presented in this manuscript.

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