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Development of Moodle-Based Learning Management System Integrated with Virtual Programming Lab for Basic Vocational Subjects of Software and Game Development

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Abstract: Programming instruction in Vocational Basics for Software and Game Development (PPLG) often encounters challenges such as limited lab practice time, restricted learning media, and conventional one-way teaching methods. This study aims to develop a Moodle-based Learning Management System (LMS) integrated with a Virtual Programming Lab (VPL) that is valid, practical, and effective. Utilizing the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), the LMS was tested on 36 grade X PPLG students at SMKN 2 Padang. Results showed high validity with a score of 4.4 (highly feasible), practicality scores of 5.0 (teachers) and 4.4 (students) (highly practical), and effectiveness with an N-gain of 0.80 (high). The findings indicate that the LMS significantly enhances learning outcomes, offering a flexible and effective solution for teaching Vocational Basics. This study concludes that the Moodle-based LMS with VPL integration is a viable tool to address existing instructional challenges in PPLG education.

Keywords: Learning management system; Moodle; Software and game development; Virtual programming lab; Vocational basics

Introduction

Education is a cornerstone in building high-quality and globally competitive human resources. In the digital era, leveraging technology in education is crucial to enhance learning quality and effectiveness. One such technological tool is the Learning Management System (LMS), a digital platform designed to facilitate online teaching and learning, thereby improving flexibility and efficiency (Rahman et al., 2019). At SMKN 2 Padang, the Software and Game Development program prepares students to become professionals in this field. A core subject for grade 10 students, Vocational Basics in Software and Game Development, provides foundational knowledge and skills essential for software and game development.

However, observations and interviews conducted at SMKN 2 Padang from January 30 to March 19, 2024, revealed significant challenges. Conventional teaching methods dominate, with teachers as the primary knowledge source and students passively receiving information. Although digital tools like WhatsApp are used, their functionality is limited to distributing materials and assignments, lacking deep interaction or hands-on practice. According to Nagaletchimee (2019), WhatsApp has limitations, including unstructured material organization, inadequate assessment features, and a lack of interactivity, hindering effective learning. Additionally, limited class time and space restrict comprehensive coverage of complex topics, leaving students struggling to grasp and apply critical concepts.

The lack of interactive and engaging learning resources further exacerbates the problem. Materials are

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often presented as static textbooks or PowerPoint slides, failing to actively involve students in coding practices. This diminishes student motivation and interest, negatively impacting learning outcomes (Means et al., 2014).

To address these issues, this study proposes the development of a Moodle-based LMS integrated with a Virtual Programming Lab (VPL) for the Vocational Basics in Software and Game Development subject. This integration offers a novel solution by combining the structured, flexible learning environment of Moodle with the interactive, hands-on coding practice provided by VPL. Moodle, a widely used open-source LMS, supports customizable learning experiences, interactive features, and progress tracking (Costa et al., 2014). Meanwhile, VPL enables students to practice coding in an interactive, collaborative environment, supporting multiple programming languages (Olivya et al., 2021).

The novelty of this research lies in its holistic approach to addressing the limitations of conventional teaching methods and existing digital tools. By integrating Moodle and VPL, this study provides a structured yet flexible learning platform that bridges theory and practice. It allows students to access materials and practice coding anytime, anywhere, overcoming time and space constraints. Additionally, the interactive and collaborative features of VPL enhance student engagement and motivation, fostering deeper understanding and better learning outcomes.

This research is significant because it responds to the growing demands of the software and game development industry, which requires graduates with strong practical skills. By providing a more effective and engaging learning environment, this LMS-VPL integration not only improves student outcomes but also equips them with the skills needed to thrive in a competitive industry. Thus, this study represents a critical step forward in vocational education, offering a scalable and adaptable solution for similar programs.

Method

This study employs the Research and Development (R&D) method is a type of research that aims to develop products and test the effectiveness of these products, starting from analyzing needs to conducting product trials so that they can be widely applied, especially in the context of education in schools (Sugiyono, 2020). The development model used in this research is the ADDIE (Analysis, Design, Development, Implementation, and Evaluation). This model was selected because it offers a systematic approach to developing, implementing, and evaluating learning products. The research subjects are 36 Grade 10 students from the Software and Game Development vocational program at SMKN 2 Padang, enrolled in the Basic Vocational Competencies course for Software and Game Development. The development model used in this research is the ADDIE model (Analysis Design-Develop-Implement-Evaluate). The flow of this ADDIE development model can be seen in Figure 1.

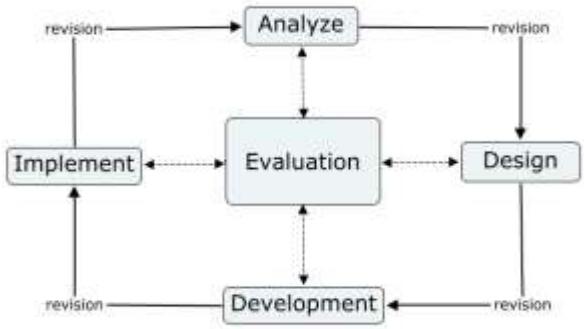

Figure 1. ADDIE model development

In this research, the ADDIE Model (Analysis, Design, Development, Implementation, and Evaluation) was used as a framework for developing interactive learning media. The ADDIE model was chosen because it is a systematic and structured model that can be used in various types of educational product and learning resource development. This model facilitates an effective and efficient development process by ensuring that each stage is thoroughly completed before moving to the next stage.

The first stage in the ADDIE Model is Analysis. At this stage, needs analysis is conducted. Needs analysis is performed to identify the gap between the current conditions and the expected conditions, so that an appropriate solution can be determined. This includes Learning Management System Development Analysis to determine that the Learning Management System development is truly needed by users, followed by curriculum analysis and product needs analysis. The second stage is Design. In this stage, interactive learning media design is carried out based on the previous analysis results. Design includes determining learning objectives, selecting learning strategies, content development, media selection, and learning flow development. In this stage, a storyboard is created as a guide for interactive learning media development.

The third stage is Development. At this stage, interactive learning media is developed according to the design created in the previous stage. Development includes creating multimedia content (text, images, audio, video), programming, and integrating all components into a complete interactive learning media. In this stage, formative evaluation is also conducted to ensure the quality of the developed media. The fourth stage is Implementation. In this stage, the developed

interactive learning media is implemented in the learning process. Implementation can be done directly in the classroom or through online learning. During the implementation process, observation and evaluation are conducted to assess the effectiveness of the learning media in achieving learning objectives.

The final stage is Evaluation. At this stage, summative evaluation is conducted to assess the overall development process and the quality of the final interactive learning media product. Summative evaluation can be done by collecting feedback from students, teachers, and learning media experts. The evaluation results can be used as input for further improvement and development.

The ADDIE Development Model provides a systematic and structured framework for developing high-quality interactive learning media. Each stage in this model is interconnected and supports one another, resulting in a final product that meets the needs and characteristics of students, and is effective in achieving the predetermined learning objectives.

The validity analysis uses a Likert scale based on the validation sheet. The validity score was given using the Equation 1.

$$P = \frac{\text{Number of scores for each criterion selected}}{\text{Total ideal score}} \times 100\% \quad (1)$$

Description:
P: Validator percentage gain

The criteria for the level of achievement of the validity test by experts in the development of Learning Management System listed in Table 1.

Table 1. Achievement level of learning management system validity

Achievement Level (%)	Qualifcation
81–100	Very feasible
61–80	Feasible
41–60	Feasible enough
21–40	Less feasible
≤ 20	Not feasible

(Sugiyono, 2014)

Practicality analysis uses a Likert scale based on the practicality sheet. Practicality scores were given using the Equation 2.

$$P = \frac{\text{Number of scores for each criterion selected}}{\text{Total ideal score}} \times 100\% \quad (2)$$

Description:
P: User percentage gain

The criteria for the level of achievement of the validity test by experts in the development of Learning Management System listed in Table 2. The Learning Management System effectiveness test was analyzed using normal gain to determine the improvement that occurred in the pre test and post test after being given treatment using the Equation 3.

$$g = \frac{\text{Post test score} - \text{Pre test score}}{\text{Maximal score} - \text{Pre test score}} \quad (3)$$

Description:
g: gain

Table 2. Achievement level of learning management system practicality

Achievement Level (%)	Qualification
81–100	Very practical
61–80	Practical
41–60	Practical enough
21–40	Less practical
≤ 20	Not practical

(Sugiyono, 2014)

The results obtained are categorized according to Table 3.

Table 3. Normalized gain category

Value (g)	Classification
$g < 0.30$	Low
$0.70 > g \geq 0.30$	Medium
$g > 0.70$	High

(Syafril, 2019)

The interpretation of the N-gain category in the form of percent (%) listed in Table 4.

Table 4. Normalized gain effectiveness interpretation category

N-Gain Percentage (%)	Interpretation
< 40	Ineffective
40–55	Less effective
56–75	Effective enough
> 76	Effective

(Syafril, 2019)

Result and Discussion

This research was conducted based on the development stages of the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The results of the research conducted are described as follows:

Analyze

The development of a Moodle-based Learning Management System (LMS) integrated with a Virtual Programming Lab aims to address several challenges faced in teaching the Vocational Subject for Software and

Game Development at SMKN 2 Padang. Based on an analysis of various issues, the system is designed to overcome these challenges and improve the overall learning experience (Ika et al., 2022).

One of the main obstacles in classroom learning is the limitation of time and space for delivering complex subject matter. Traditional classroom settings often fail to provide sufficient time for students to fully grasp programming concepts. The Moodle-based LMS provides a solution by offering online access to learning materials, allowing students to study anytime and anywhere (Yauma et al., 2020). This system enables students to explore learning content beyond classroom hours, eliminating constraints related to physical space and time (Swastika et al., 2020). Furthermore, the integration of the Virtual Programming Lab allows students to practice coding directly from their devices, mitigating the issue of limited access to laboratory facilities, which has been a major barrier in practical learning (Mahmud et al., 2021). Studies have shown that LMS platforms significantly improve the flexibility and accessibility of learning, making education more efficient and engaging (Nurchayati & Gunawan, 2023).

Previously, learning activities relied on WhatsApp as the primary communication and material distribution platform. However, WhatsApp lacks the structure necessary for organizing learning materials systematically. The Moodle-based LMS offers a more structured platform for managing course content, assignments, and student activities (Andari, 2022). Teachers can easily upload learning materials in various formats and organize a clear learning flow that students can follow effectively. The system also facilitates better learning management through features such as automated notifications, discussion forums, and integrated evaluation tools (Sulistyorini & Anistyasari, 2020). Structured LMS environments provide a more effective learning experience by ensuring seamless content delivery and interaction between students and teachers (Wiragunawan, 2022).

Another major issue in classroom learning is its one-directional nature, where teachers predominantly deliver lectures while students passively receive information. The Moodle-based LMS transforms this dynamic by incorporating interactive features such as discussion forums, quizzes, and hands-on assignments that encourage active student participation (Asrini et al., 2021). Additionally, the Virtual Programming Lab allows students to apply theoretical knowledge in real-time through coding exercises, fostering a deeper and more interactive learning experience. Research supports the idea that interactive learning environments lead to better student engagement and understanding, particularly in programming education (Cahyadi, 2019).

The use of traditional learning resources, such as textbooks and PowerPoint presentations, has often been found to be less engaging for students, resulting in a lack of active participation (Sam & Idrus, 2021). Through Moodle, learning materials can be presented in various interactive formats, such as video tutorials, simulations, and hands-on coding exercises that students can complete directly within the platform. With the integration of the Virtual Programming Lab, students can experiment with different coding examples and small projects, making learning more engaging and aligned with industry needs (García, 2024). The incorporation of multimedia content in LMS-based learning has been proven to enhance student motivation and retention (Yana & Adam, 2019).

Practical coding sessions in the classroom are often limited due to infrastructure constraints and the applications used. By integrating a Virtual Programming Lab within the LMS, students can practice coding directly on the platform without the need to install additional software. This feature enables students to engage in interactive learning, complete coding assignments with automated feedback, and even collaborate with peers on group projects. Such an environment fosters a more collaborative and exploratory learning experience, which is essential for developing programming skills effectively (Maulana et al., 2025). LMS platforms with interactive programming tools significantly enhance student learning outcomes and foster problem-solving skills.

As a vocational institution, SMK requires a more practical and industry-relevant learning approach. The Moodle-based LMS, enhanced with a Virtual Programming Lab, provides students with a more structured and practical learning experience in software and game development. This system not only facilitates independent access to learning materials but also promotes continuous learning through automated assessments and progress tracking, allowing teachers to monitor students' coding proficiency (Harefa, 2020).

Through the development of this Moodle-based LMS, the previously conventional and passive learning approach is transformed into a more dynamic, interactive, and vocationally relevant system. By integrating structured content delivery, hands-on coding practice, and interactive assessments, this LMS aligns with the digital era's educational needs, ensuring students gain essential programming skills efficiently and effectively. The integration of technology in education, particularly through LMS platforms, has been widely recognized as an effective strategy for improving student engagement, learning flexibility, and overall educational quality (Rahayu & Sukardi, 2021). The analysis of the curriculum or material on Physics

subjects developed into Learning Management System as shown in Table 5.

Table 5. Learning materials and objectives

Learning Outcome Elements	Coding Practice Material
Basic orientation of software and game development (Students are able to understand the basic concepts of network systems and various operating systems, implement the use of software and game development tools and applications, implement asset management, UI (User Interface), and programming algorithms).	- Basic concepts of network systems and operating systems -Use of development tools devices and applications -Asset management -UI (User Interface) -Programming algorithms
Structured programming (Students are able to apply structured programming to simple software and game development projects).	-Introduction to Structured Programming -Introduction to Functions and Procedures in Structured Programming -Basic Operations and Control Structures -Repetition Structures in Structured Programming
Object-oriented programming (Students are able to apply basic object-oriented programming to simple software and game development projects).	-Introduction to OOP and Basic Concepts (Java) -Inheritance in OOP (Java) -Polymorphism (java) -Encapsulation with Python -Inheritance with Python -Polymorphism with Python
Web programming (Students are able to apply server-side programming languages, frameworks, and documentation in creating static and dynamic websites for various contextual needs).	-Hypertext Markup Language

After conducting curriculum analysis, the next stage was product needs analysis. Based on interviews with subject teachers, the researchers successfully identified and formulated essential requirements for developing a Moodle Learning Management System (LMS) integrated with Virtual Programming Lab. The results of this analysis are divided into two main categories: functional requirements and non-functional requirements.

In terms of functional requirements, the system must possess several essential capabilities. First, the system should enable teachers to easily create and manage courses, including the ability to provide various learning content such as text, videos, and quizzes (Bradley, 2020). Second, the LMS must support learning material management in various formats to accommodate diverse student learning preferences (Supiani et al., 2024). Third, the system needs to be equipped with coding assignment features that allow teachers to assign and efficiently manage assignment submissions (Rauf et al., 2023). Fourth, integration with Virtual Programming Lab becomes a key feature that enables students to conduct online coding activities, providing interactive and practical learning experiences (Prahani et al., 2022). Fifth, the system must have the capability to assess coding assignments and provide constructive feedback to support student learning processes (Muhammad, 2017). Sixth, the system must facilitate communication between teachers and students to support productive collaboration and discussion in the learning process (Rosidin et al., 2021).

Meanwhile, for non-functional requirements, there are three main aspects to consider. First, system performance must be able to operate smoothly and effectively even under heavy user access conditions (Achaqie et al., 2022). Second, an intuitive and user-friendly interface is crucial to ensure ease of LMS operation for both teachers and students (Biya et al., 2024). Third, the system must have mechanisms that facilitate maintenance and updates to maintain relevance and the ability to evolve according to needs (Ozaga & Arzi, 2022).

Design

After completing the analysis phase in the ADDIE model, the research proceeded to the design phase. At this stage, the authors designed a Moodle-based Learning Management System (LMS) integrated with Virtual Programming Lab based on the results of the previous analysis. This design process produced two main components: learning flow design and user interface design.

In designing the learning flow in Moodle LMS, the authors adapted the conventional learning structure consisting of opening activities, core activities, and closing activities. This learning flow was systematically designed by considering the results of the previously conducted needs analysis and aligned with the intended learning objectives. This structure ensures continuity and order in the digital learning process.

Meanwhile, user interface design became a crucial focus in the development of this LMS. Several key aspects considered in the interface design include implementing a clean and minimalist design to maximize user focus on learning content. The navigation system was designed with principles of clarity and consistency to facilitate users in exploring the platform. Visual aspects also received special attention through the selection of an attractive color scheme appropriate for vocational high school students as the primary users (Silalahi et al., 2021). To enhance system intuitiveness, the interface is equipped with icons and symbols

familiar to students, making it easier for them to understand and operate the various features available in the LMS.

Development

The development phase encompassed three main components: LMS development, instrument development, and LMS product assessment. The product development process was carried out according to the previously designed specifications, requiring one month to complete the LMS comprehensively, from Moodle installation to publication. Throughout the development process, researchers collaborated with subject teachers to ensure the LMS met the identified learning requirements.

LMS development began with the system installation on hosting. The first step was to purchase a hosting package and domain by selecting a c-Panel package to support Moodle-based LMS development. The c-Panel package selection was based on the system's need to accommodate various learning content such as videos, PDF documents, and other learning media. The domain chosen was pplg.smkn2.com, providing a specific identity reflecting PPLG learning.

After the hosting and domain were activated, the development process continued with the installation of Moodle LMS version 4.4.2 through the c-Panel account. Prior to installation, a "db_moodle" database was created through the MySQL Databases menu in cPanel as the system's data storage. The Moodle installation process began with accessing the domain through a browser, followed by initial configuration including language settings, data directory, and database connection. At this stage, the main administrator account was also configured, which would have full control over the system.

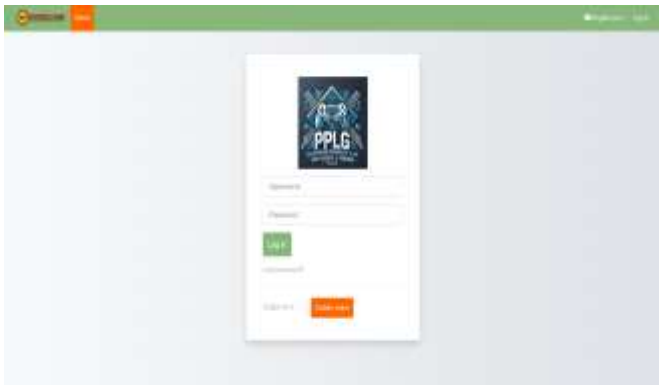

Figure 2. LMS login page view after configuring moodle theme

Following the installation, development continued with theme and display configuration according to the previously designed specifications, taking into account user experience (UX) and user interface (UI) aspects (Putri & Candra, 2023). The system was developed with three user access levels: admin, teacher, and student, where each level has a dashboard tailored to their respective needs and roles. The admin dashboard is equipped with user management features enabling account addition, editing, and deletion, ensuring effective and structured system management.

Figure 3. LMS home page view

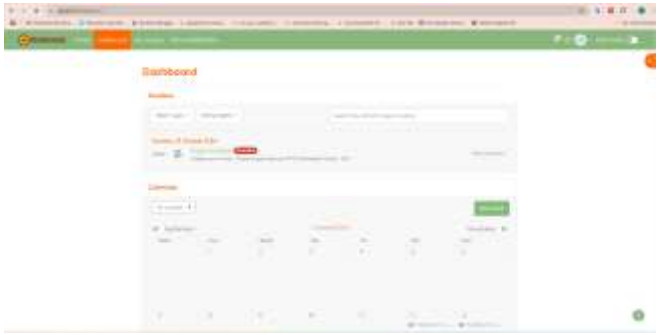

Figure 4. LMS dashboard page

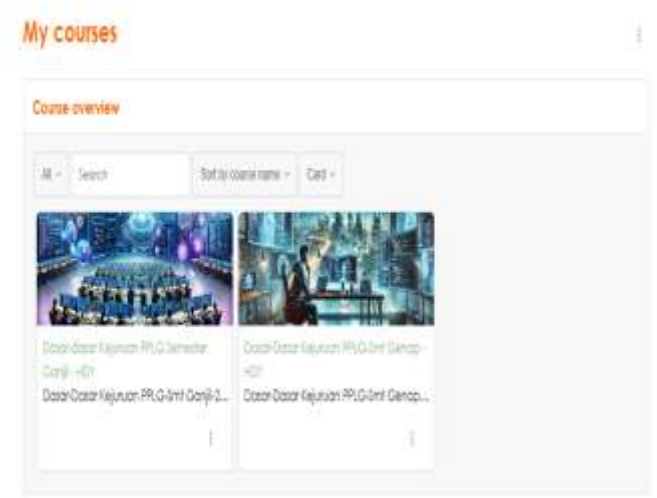

Figure 5. LMS course page

Figure 6. Course content page

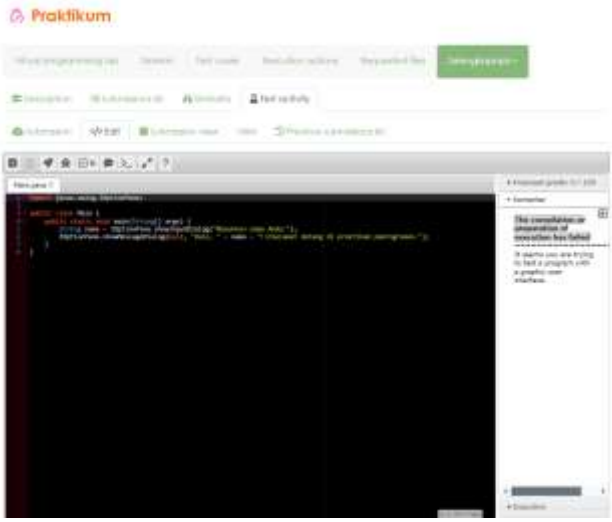

Figure 7. Coding practice activity page

Learning Management System is validated by 3 experts, namely media, material and language experts. This refers to research by Suyoso & Nurohman (2014) which explains that the validation process of technology-based learning media needs to be assessed from material aspects, media aspects, and language aspects to ensure its feasibility for use in learning.

The results of instrument validation can be seen in Table 6.

Table 6. Validation instrument results

Instrument Type	Score%	Category
validity instrument	92	Very high validity
Practicality Instrument	92	Very high validity
overall percentage	92	Very high validity

The results of the Learning Management System validation in the fields of material, language and media can be seen in Table 7.

Table 7. Learning management system validation results

Validation Type	Percentage%	Category
Media Expert	92	Very feasible
Material Expert	78	Very feasible
Language Expert	96	Very feasible
Average	89	Very feasible

Referring to the validity criteria category, the results of the Learning Management System validity are included in the very feasible category. The results of the media and material validation in this study also strengthen the findings of the study (Munandar et al., 2022), which developed a Moodle-based LMS for Trigonometry material. Munandar et al. (2022) emphasized the importance of interactive features such as SCORM and H5P to enhance students' learning experiences. The results of the material, language and media validity analysis of the Learning Management System can be seen in Figure 8.

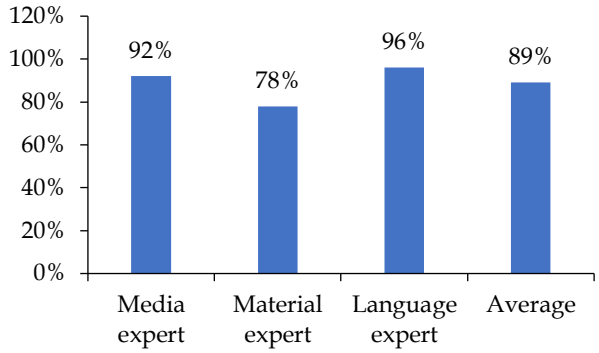

Figure 8. Validation result diagram

Implementation

In this section is the assessment of the Learning Management System in terms of practicality. The Practicality Test includes an assessment of teacher and student responses listed in Table 8.

Table 8. Learning management system practicality results

Aspect	Teacher Percentage (%)	Student Percentage (%)	Category
Ease of Use	100	89	Very practical
Learning Effectiveness	100	89	Very practical
Motivation to learn	100	88	Very practical
Interactivity	100	88	Very practical
Flexibility	100	89	Very practical
Benefit	100	88	Very practical
User Satisfaction	100	86	Very practical
Average	100	88	Very practical

The results of the student practicality tests can be seen in Figure 9 and the results of the teacher practicality tests can be seen in Figure 10. The results of the teacher's practicality assessment on the Learning Management System show that the average percentage of teacher response assessment is in the very practical category with a percentage of 100%, very practical, meaning that the Learning Management System is in accordance with predetermined criteria. Practicality sheets on students were filled out by 36 students at the final meeting of the trial. In summary, the results of the practicality of student responses to Learning Management System with a percentage of student responses to the practicality of Learning Management System are 88% with a very practical category.

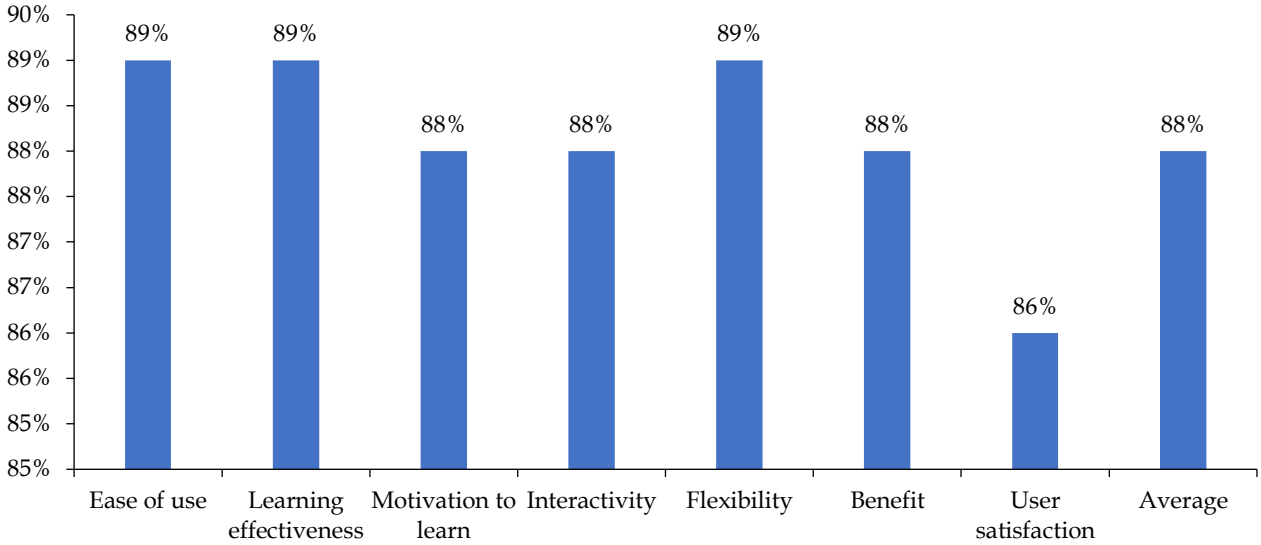

Figure 9. Diagram of student practicality result

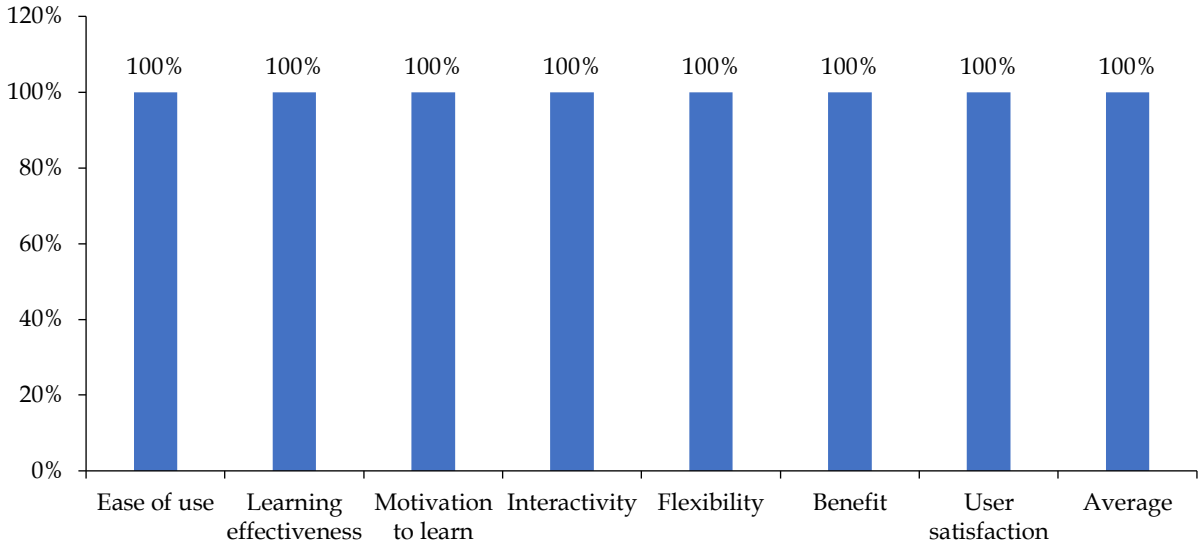

Figure 10. Diagram of teacher practicality result

The effectiveness of the Learning Management System was analyzed using the one group pretest and posttest technique on students with an average pretest result of 42.22 and the posttest increased to 89.72 and the N-gain score and N-gain percentage were obtained as seen in Table 9.

Table 9. Aspect of effectiveness gain value

	N	Min	Max	Mean	Std. Dev
N-gain score	36	57	1.00	0.80	.14128
N-gain percentage	36	57	100	80.82	14.128

Based on Table 9, the N-gain score is 0.80 (g > 0.7) and is classified as high with an N-gain percentage of

80%, so it is categorized as effective. The results of this study are reinforced by research from Fonna et al. (2022) that the Learning Management System integrated with the Virtual Programming Lab is not only feasible to use, but also very effective in improving the quality of learning. Then also supported by research from Kurniawan et al. (2022), which proves that LMS integration with external tools such as Wondershare Quiz Creator can improve students' understanding and interest in learning. In this study, the integration of the Virtual Programming Lab has a more significant impact, because it provides direct practical experience in completing programming assignments. In addition, the results of this study are also consistent with the findings of Setiawan et al. (2020), who developed the Moodle-based Academiana e-learning. Setiawan et al. (2020) shows the effectiveness of LMS in improving conceptual understanding in the Educational Communication course. However, this study goes further by providing a more practical and contextual learning environment for vocational high school students majoring in software and game development.

Evaluation

The evaluation phase is a crucial component in the development of the Virtual Programming Lab Integrated Learning Management System (LMS). This evaluation aims to assess the effectiveness, practicality, and quality of the developed product. Through analysis of user perceptions, learning outcomes, and product improvements, several important points indicating the positive impact of this LMS have been identified. Student perceptions of the LMS indicate that they found it helpful in their learning process. The received comments reflect satisfaction and recognition of the presented innovations, where they experienced ease of access and clarity in using the LMS. This shows that the LMS not only functions as a learning aid but also increases students' motivation for independent learning. Teacher feedback also confirms that this LMS aligns with student needs, demonstrating its relevance and effectiveness in the learning context (Khunaini & Sholikhah, 2021).

In terms of learning outcomes, pre-test and post-test evaluations show significant improvements. The increase in average scores from 42.22 to 89.72 indicates that the use of this LMS contributes to enhanced student understanding and skills. The high average N-gain score signifies that the learning method implemented through this LMS is effective in improving learning outcomes, which is the main objective of LMS development.

Product improvements based on suggestions from the Expert Team and users also become an important aspect of this evaluation. Responsive improvement actions to feedback demonstrate the commitment to continuously enhance LMS quality. By adding relevant features and improving deficient aspects, this LMS is expected to meet user expectations and enhance the overall learning experience.

The results of the evaluation with Raman et al. (2014) research show that the interactive e-learning function can effectively attract students' interest and attention, while facilitating collaboration and knowledge sharing. What is especially noteworthy is the role of social and environmental factors as the main motivators for technology adoption in educational environments. This study shows that encouragement and support from colleagues are essential to accelerate implementation.

Overall, this evaluation phase not only assesses the developed product but also provides valuable insights for further development. By integrating user feedback and evaluation results, the Virtual Programming Lab Integrated LMS can be continuously refined to achieve better educational objectives.

Conclusion

The development of a Moodle-based Learning Management System (LMS) integrated with Virtual Programming Lab (VPL) using the ADDIE model has successfully addressed the challenges in teaching Vocational Basics for Software and Game Development (PPLG). The system demonstrated high validity with a score of 4.4, strong practicality with scores of 5.0 from teachers and 4.4 from students, and significant effectiveness with an N-gain of 0.80. These results indicate that the integrated LMS effectively overcomes the limitations of traditional programming instruction, including restricted lab time and conventional teaching methods. The system provides a flexible and interactive learning environment that enhances student learning outcomes in PPLG education. This research confirms that a Moodle-based LMS with VPL integration serves as a viable solution for modernizing vocational programming education.

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Author Contributions

Finding research-related problems, developing research instruments, developing Learning Management System, writing initial drafts, providing draft ideas, reviewing and editing, monitoring research progress, and providing feedback

on research. All authors contributed to the content and every part of this article. We have read and approved the published version of the manuscript.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Achaqie, H. N. R., Sediyono, E., & Prasetyo, S. Y. J. (2022). Evaluasi Kinerja Pembelajaran Learning Management System Menggunakan COBIT 4.1 pada Universitas STEKOM Semarang. *Elkom: Jurnal Elektronika dan Komputer*, *15*(1), 97–107. https://doi.org/10.51903/elkom.v15i1.788

Andari, E. (2022). Implementasi Kurikulum Merdeka Belajar Menggunakan Learning Management System (LMS). *Allimna: Jurnal Pendidikan Profesi Guru*, *1*(2), 65–79. https://doi.org/10.30762/allimna.v1i2.694

Asrini, H. W., Wicaksono, G. W., Budiono, B., Ramadhan, G., & Wahyuni, E. D. (2021). Recommended Features of Learning Management System Using Feature-Oriented Method Software Development on Moodle. *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control*, *6*(4). https://doi.org/10.22219/kinetik.v6i4.1354

Biya, A. N. A., Kolibu, M. J., Mambu, J. Y., & Tangka, G. M. W. (2024). Desain UI/UX Aplikasi Unklab Mobile Student Dengan Metode Design Thinking. *Journal Cerita: Creative Education of Research in Information Technology and Artificial Informatics*, *10*(2), 145-156. https://doi.org/10.33050/cerita.v10i2.3362

Bradley, V. M. (2020). Learning Management System (LMS) Use with Online Instruction. *International Journal of Technology in Education*, *4*(1), 68. https://doi.org/10.46328/ijte.36

Cahyadi, R. A. H. (2019). Pengembangan Bahan Ajar Berbasis Addie Model. *Halaqa: Islamic Education Journal*, *3*(1), 35–42. https://doi.org/10.21070/halaqa.v3i1.2124

Costa, C., Alvelos, H., & Teixeira, L. (2014). The Use of Moodle E-Learning Platform: A Study in a Portuguese University. *Procedia Technology*, *5*, 334–343. https://doi.org/10.1016/j.protcy.2012.09.037

Fonna, M., Marhami, M., Rohantizani, R., & Herizal, H. (2022). Pengembangan Learning Management System (LMS) Berbasis Moodle di Masa Pandemi Covid-19. *Aksioma Jurnal*, *11*(1), 493–503. http://dx.doi.org/10.24127/ajpm.v11i1.4489

García, A. L. S. (2024). Use of Virtual Programming Lab and H5P Tools for Learning Programming in Higher Level Students. *RIDE Revista Iberoamericana para la Investigación y el Desarrollo Educativo*, *15*(29). https://doi.org/10.23913/ride.v15i29.2153

Harefa, N. (2020). *Learning Management System Aplikasi E - Learning untuk Pembelajaran Online dan Blended*. Jakarta: UKI Press.

Ika, N., Rakhmawati, S., Mardliyah, S., Fitri, R., & Laksono, K. (2022). Pengembangan Learning Management System (LMS) di Era Pandemi Covid-19 pada Pendidikan Anak Usia Dini. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia dini*, *6*(1), 107–118. https://doi.org/10.31004/obsesi.v6i1.991

Khunaini, N., & Sholikhah, N. (2021). Pengaruh Penggunaan Learning Management System Google Classroom dan Gaya Mengajar Guru Terhadap Motivasi Belajar pada Pembelajaran Daring. *Edukatif: Jurnal Ilmu Pendidikan*, *3*(5), 2079–2091. Retrieved from https://edukatif.org/index.php/edukatif/article/view/737

Kurniawan, D., Ambiyar, A., & Effendi, H. (2022). Pengembangan Learning Management System (LMS) Terintegrasi Wondershare Quiz Creator pada Bimbingan Teknologi Informasi dan Komunikasi. *JRTI*, *7*(3), 432–437. https://doi.org/10.29210/30032041000

Mahmud, M. E., Widat, F., & Fuadi, A. (2021). Learning Management System in Streamlining Learning through Seamless Learning Approach. *Al-Ishlah Jurnal Pendidikan*, *13*(2), 874-884. https://doi.org/10.35445/alishlah.v13i2.787

Maulana, I., Supriyadi, E., Wijanarka, B. S., Ariyatun, A., & Winarto, W. (2025). Coding Learning Innovation: Interactive Programming Experience with Virtual Lab Platform. *Multidisciplinary Science Journal*, *7*(6), e2025262. https://10.31893/multiscience.2025262

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2014). Evaluation of Evidence-Based Practices in Online Learning. *Structure*, 66. Retrieved from www.ed.gov/about/offices/list/opepd/ppss/reports.html

Muhammad, T. (2017). Perancangan Learning Management System Menggunakan Konsep Computer Supported Collaborative Learning. *Jurnal Produktif*, *1*, 35–63.

Munandar, A. H., Amrullah, A., Junaidi, J., & Arjudin, A. (2022). Pengembangan Media E-Learning Berbasis Learning Management System (LMS) Moodle pada Materi Trigonometri di Kelas X SMAN 1 Lingsar. *Griya Journal of Mathematics Education and Application*, *2*(3), 841–852. Retrieved from https://mathjournal.unram.ac.id/index.php/Griy

a/article/view/227

Nagaletchimee, A. (2019). Using Whatsapp to Extend Learning. *Teaching English with Technology*, *19*(1), 3–20. Retrieved from https://content.ebscohost.com/ContentServer.asp?EbscoContent=dGJyMNHr7ESeprI4zdnyOLCmsEieprdSs6m4S66WxWXS&ContentCustomer=dGJyMPGssVGup7VRuePfgeyx9Yvf5ucA&T=P&P=AN&S=R&D=eue&K=134817798

Nurchayati, A. D., & Gunawan, Y. I. P. (2023). Efektivitas Learning Management System Terhadap Pelayanan Administrasi Pembelajaran di MTs Plus Nurul Falah Jabres. *Jurnal Kridatama Sains dan Teknologi*, *5*(02), 278–294. https://doi.org/10.53863/kst.v5i02.934

Olivya, M., Saharuna, Z., & Yusri, I. K. (2021). Evaluasi Implementasi Virtual Programming Lab pada E-Learning. *Jurnal Teknologi Elekterika*, *5*(2), 75. https://doi.org/10.31963/elekterika.v5i2.3022

Ozaga, A., & Arzi, A. A. (2022). Manajemen Proyek: Perancangan Learning Management System (LMS) untuk Sistem Informasi Pembelajaran dengan Menggunakan Metode Critical Chain. *SINTESIA*, *2*(1), 1. Retrieved from https://journal.unj.ac.id/unj/index.php/SINTESIA/article/view/39407

Prahani, B. K., Alfin, J., Fuad, A. Z., Saphira, H. V., Hariyono, E., & Suprapto, N. (2022). Learning Management System (LMS) Research During 1991–2021: How Technology Affects Education. *International Journal of Emerging Technologies in Learning*, *17*(17), 28–49. https://doi.org/10.3991/ijet.v17i17.30763

Putri, S. A., & Candra, F. (2023). Design of a Web-Based Learning Management System for Physics Education FKIP University of Riau. *INOVTEK Polbeng - Seri Informatika*, *8*(1), 14. https://doi.org/10.35314/isi.v8i1.2921

Rahayu, I., & Sukardi, S. (2021). The Development of E-Modules Project Based Learning for Students of Computer and Basic Networks at Vocational School. *Journal of Education Technology*, *4*(4), 398. https://doi.org/10.23887/jet.v4i4.29230

Rahman, M., Daud, M. Y., & Ensimau, N. K. (2019). Learning Management System (LMS) in Teaching and Learning. *International Journal of Academic Research in Business and Social Sciences*, *9*(11), 1529–1535. https://doi.org/10.6007/ijarbss/v9-i11/6717

Raman, A., Don, Y., Khalid, R., & Rizuan, M. (2014). Usage of Learning Management System (Moodle) Among Postgraduate Students: UTAUT Model. *Asian Social Science*, *10*(14), 186–192. https://doi.org/10.5539/ass.v10n14p186

Rauf, W., Rajab, A., & Nashruddin, N. (2023). Exploring the Learning Design on Learning Management System for Online Learning: A Case Study in Higher Education. *Jurnal Ilmiah Profesi Pendidikan*, *8*(1), 1–10. https://doi.org/10.29303/jipp.v8i1.1075

Rosidin, U., Rakhmawati, I., & Kadaritna, N. (2021). Pelatihan Aplikasi Learning Management System bagi Guru SMAN 1 Gedong Tataan untuk Meningkatkan Kualitas Pembelajaran Daring. *Jurnal Pengabdian Nasional*, *2*(1), 41–50. Retrieved from https://jurnal.polinela.ac.id/index.php/JPN/index

Sam, N. E., & Idrus, R. (2021). Efektivitas Media E-Learning Berbasis Learning Management System (LMS) di Era Pandemi Covid-19. *Jurnal Ikraith-Humaniora*, *5*(3), 11–17. Retrieved from https://journals.upi-yai.ac.id/index.php/ikraith-humaniora/article/view/1466

Setiawan, A., Mansur, H., & Mastur, M. (2020). Pengembangan E-Learning Academiana Berbasis Moodle untuk Mata Kuliah Komunikasi Pendidikan. *Journal of Instructional Technology J-INSTECH*, *1*(1), 13–19. Retrieved from https://ppjp.ulm.ac.id/journals/index.php/j-instech/article/view/3642

Silalahi, P., Agripina, C., & Agita, Y. (2021). Pelatihan Desain Pembelajaran dengan E-learning Berbasis LMS Moodle. *Journal of Applied Community Engagement*, *1*(1), 34–40. https://doi.org/10.52158/jace.v1i1.125

Sugiyono, S. (2014). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta.

Sugiyono, S. (2020). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta.

Sulistyorini, L., & Anistyasari, Y. (2020). Studi Literatur Analisis Kelebihan dan Kekurangan LMS Terhadap Pembelajaran Berbasis Proyek pada Mata Pelajaran Pemrograman Web di SMK. *IT-Edu: Jurnal Information Technology and Education*, *5*(01), 171–181. https://doi.org/10.26740/it-edu.v5i2.36692

Supiani, S., Kurniady, D. A., Yuniarsih, T., & Aedi, N. (2024). Evaluating Learning Management System (LMS) Effectiveness : An LPOMR Model Approach. *Pedagogia: Jurnal Ilmiah Pendidikan*, *16*(2), 71–77. https://doi.org/10.55215/pedagogia.v16i2.2

Suyoso, S., & Nurohman, S. (2014). Developing Web-Based Electronics Modules as Physics Learning Media. *Jurnal Kependidikan*, *44*(1), 73–82.

Swastika, A., Lukita, G., & History, A. (2020). Motivasi Belajar dalam Pembelajaran Daring Berbasis Learning Management System (LMS) Schoology pada Mata Kuliah Probabilitas. *Indonesian Journal of Instructional Technology*, *1*, 1–5. Retrieved from http://journal.kurasinstitute.com/index.php/ijit

Syafril, S. (2019). *Statistik pendidikan*. Jakarta: Kencana.

Wiragunawan, I. G. N. (2022). Pemanfaatan Learning

Management System (LMS) dalam Pengelolaan Pembelajaran Daring pada Satuan Pendidikan. *EDUTECH: Jurnal Inovasi Pendidikan Berbantuan Teknologi*, *2*(1), 83–90. https://doi.org/10.51878/edutech.v2i1.981

Yana, D., & Adam, A. (2019). Efektivitas Penggunaan Platform LMS sebagai Media Pembelajaran Berbasis Blended Learning Terhadap Hasil Belajar Mahasiswa. *Jurnal Dimensi*, *8*(1), 1–12. https://doi.org/10.33373/dms.v8i1.1816

Yauma, A., Fitri, I., & Ningsih, S. (2020). Learning Management System (LMS) pada E-Learning Menggunakan Metode Agile dan Waterfall berbasis Website. *Jurnal JTIK (Jurnal Teknologi Informasi dan Komunikasi)*, *5*(3), 323. https://doi.org/10.35870/jtik.v5i3.190