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The Effect of Moodle-Based LMS on the Cognitive Competence of Electronic Fuel Injection System Maintenance in Students of SMK Muhammadiyah 2 Semarang

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Abstract

The advancement of technology in education requires innovative teaching methods, especially for practical subjects such as the maintenance of the Electronic Fuel Injection (EFI) system in Vocational High Schools. This study aims to examine the impact of a Moodle-based Learning Management System (LMS) on the competence of students in periodic maintenance of the EFI system. The research explores how the implementation of a validated LMS affects the academic performance of students. The data was collected through tests to assess learning outcomes after using the LMS. The results were analyzed in two phases: preliminary tests and data analysis. The preliminary tests showed positive results, where normality and homogeneity tests indicated that the data were normally distributed and homogeneous. The data analysis, which involved t-tests, revealed significant differences between the posttest scores of the control group and the experimental group. The t-test analysis showed a p-value of 0.00, which is less than 0.05, indicating a significant difference in posttest scores between the experimental and control groups. The n-gain test in the control group showed a value of 0.487, indicating a moderate improvement, while the n-gain test in the experimental group, which used the LMS, showed a value of 0.702, indicating a high level of improvement. Based on the analysis, it can be concluded that the developed LMS has had a significant impact on the learning outcomes of students, reflecting their competence in periodic maintenance of the EFI system.

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INTRODUCTION

Education is essentially a process of transferring human resources from one generation to the next. Education plays a fundamental role in shaping the foundation of a nation. High-quality human resources are considered a vital factor for sustaining the development of any country (Nguyen Thi HANG, 2021). Education is a "deliberate and planned effort to create an atmosphere of learning and teaching that encourages students to actively develop their potential in areas such as spiritual religious strength, self-control, personality, intelligence, moral character, and skills that benefit both themselves and society" (Annisa, 2022)(Zuhdi et al., 2021). Thus, every process within a place, in all its aspects, is determined by the quality of education in that place. The quality of a nation reflects the quality of its education.

Vocational education, as part of the broader education system, prepares individuals to perform a variety of tasks or jobs in specific sectors (Adi, N. H., Riyanda, A. R., 2023). Vocational education and vocational training are often viewed as having distinct meanings, but at their core, they share the same goal: to prepare graduates for the workforce or the industrial world (Arnita & Fadriati, 2022)(Lund & Karlsen, 2020). Vocational education in Indonesia plays a crucial role in preparing human resources who are capable of competing in the job market. Vocational schools, as part of vocational education, are expected to cultivate innovative, creative, competitive, and sustainable characters, requiring both sociocultural and structural support (Yudiono et al., 2019)(Putriana et al., 2024). One key area for development is automotive technology, which equips students to become skilled automotive mechanics. The automotive sector continues to evolve, and these advancements should be mirrored in the education system that addresses them. To achieve the goals of education, a learning and teaching process, often referred to as the learning process, is essential. Learning is a set of actions designed to support the student learning process, considering external factors that influence internal events within the student (De Juana-Espinosa et al., 2023)(Nicolaou et al., 2019). Learning can be understood as a change in an individual's behavior resulting from interactions between individuals and their environment, enabling them to better engage with their surroundings (Kurniawati & Azka, 2022). Selecting the right learning model is expected to enhance the students learning experience and competence after completing the course (Yudiono et al., 2021).

In the vocational school (SMK) learning process, several challenges are faced by teachers. These include a lack of resources to develop quality teaching materials and limited time and facilities to provide sufficient practical experiences to students. The 21st century marked the beginning of significant advancements, particularly in the field of technology. The development of information technology has been rapid and influential across various sectors (Sardi et al., 2023). All aspects of life are undergoing digitalization, including education. Vocational education must align with technological developments, societal needs, individual needs, and the demands of the labor market (Yudiono, 2017). Digitalization is being applied in various processes, from administration to teaching. This process aims to familiarize educators, students, and academic communities with technology, reducing the gap in technology use within educational environments, which will ultimately be carried over to society. Thus, there is a need for vocational education teachers who are forward-looking, capable of working collaboratively, adaptable, and capable of adjusting to industry advances and the dynamics of vocational education (Yudiono et al., 2022)(Baitullah & Wagiran, 2019).

Some schools have started implementing rules allowing students to bring gadgets to school. This policy aims to aid the learning process. Why is this? Gadgets are considered more practical compared to traditional learning tools such as books. Over time, gadgets have replaced several learning aids. The first advantage of gadgets is their large storage capacity, as well as their flexibility and portability, although storage size varies depending on the gadget's brand, compared to traditional books (Restela & Putri, 2023). Gadgets can now store books, images, videos, and even learning aids all in one device.

Gadgets, also referred to as mobile phones, smartphones, and other terms, facilitate mobile learning, allowing teachers to teach flexibly at any time and place using mobile devices such as smartphones or tablets, which is both time- and cost-efficient (Maheswari et al., 2024). However, gadgets are often misused. Students tend to use gadgets for entertainment, from playing games to social media. The real challenge for innovation in e-learning is to find the correct mix of techniques, as the mix greatly depends on application areas, students, and scenarios (Maurer, 2017). The causes of this misuse include lack of teacher supervision and insufficient learning materials available on students devices. Games or other forms of entertainment on gadgets are more appealing to students than the learning material provided by their teachers. It is often observed that students are more engaged with their phones than paying attention to their teachers, which undermines the goal of the regulation.

As a solution to this challenge, the use of digital learning technologies can be an effective and efficient alternative. Moodle is one popular digital learning platform widely used by teachers globally. Moodle provides various features that can help teachers develop and present learning materials interactively and engagingly. Various learning media can be integrated into this platform, such as images, videos, audio, and animations. Learning media in these formats are considered more engaging because students are not only focusing on their auditory senses when the teacher uses the lecture method. With different types of media, all five senses can be utilized, which supports the process of learning material more effectively.

Observations at SMK Muhammadiyah 2 Semarang showed that the scores for the subject of Competency Skills have not met the criteria for successful learning. In both classes, only 60% and 55% of students passed the Learning Goal Achievement Criteria (LGAC). This indicates that not all students have mastered the learning material. Learning is considered successful when 75% of students master the material and achieve evaluation results above the LGAC (Lestari, 2019)(Winget & Persky, 2022)(Pelánek & Řihák, 2018). This implies that changes, both internal and external, are necessary. Successful learning occurs when teachers can systematically and carefully plan or design the learning process. One key component that needs attention in lesson planning is the selection of appropriate learning media that suit the material being taught and also capture students interest in learning (Moto, 2019).

METHODS

This study aims to examine the impact of the learning media provided by the Moodle-based LMS for EFI (Electronic Fuel Injection) system maintenance. To measure this impact, tests were used as tools to assess students ability in EFI system maintenance. The experiment is designed to compare the extent of the effect of the treatment on students in the experimental class, while the control class uses conventional methods only (Mushthofaina et al., 2024). Students will first undergo a pretest to determine their initial competence. Following this, students will receive the Moodle-based LMS learning treatment. Then, a posttest will be conducted to assess the improvement in their knowledge. Since multiple samples are used, this study is categorized as a pre-experimental design with an Intact Group Comparison type to compare the group that receives the intervention and the group that does not (Putri et al., 2023)(Riyan Rizaldi et al., 2021)(Sahib et al., 2020)(KK et al., 2022)(Kaur & Kaur, 2025).

$$O_1 \; X \; O_2$$
$$O_3 \quad O_4$$

(Abraham & Supriyati, 2022)

To ensure that students have achieved competence in EFI system maintenance, success indicators were created as a reference for developing assessments. The assessment grid will be based on the following success indicators:

Table 1. Success Indicators

No.	Core Material	Success Indicator
1.	Understanding Electronic Fuel Injection (EFI)	Students can analyze the differences between the Electronic Fuel Injection (EFI) system and conventional systems based on their operating principles.
2.	Names and Functions of EFI Components.	Students can analyze the relationships between EFI components to support the combustion process in the engine.
3.	How EFI Works.	Students can explain the working process of the EFI system based on the input and output of the involved sensors.
4.	EFI Maintenance Procedure.	Students can analyze the steps in EFI system maintenance to identify the causes of damage or malfunction.

Preliminary Analysis Test

1. Normality Test

The normality test is performed to assess whether the data distribution in a group or variable is normal. The obtained X^2_{data} value is compared with the X^2_{tabel} table value with degrees of freedom (df) = K - 3 and a significance level of 0.05. The data is considered normally distributed if the $X^2_{table} < X^2_{table}$.

2. Homogeinity Test

The homogeneity test is used to determine whether multiple population variances are the same or not (Usmadi, 2020). In this study, the homogeneity test is applied to the posttest results of the control group. The results of the homogeneity test will be used to determine the hypothesis testing formula. For a 5% significance level, if the $F_{calculated} < F_{table}$, it indicates that the variance of both groups is homogeneous.

Data Analysis Test

1. T-Test

In this study, the t-test is used to determine whether there is a significant difference between pretest and posttest results. The t-test used is the Dependent-Samples T-Test or Paired-Sample T-Test. This test compares two means from sample groups or compares the pretest results before learning and the posttest results after learning (Putri et al., 2023). In decision making, if the significant value is greater than 0.05, the null hypothesis (H_0) is accepted and the alternative hypothesis (H_1) is rejected. This means that, partially, the independent variable does not have a significant effect on the dependent variable. If the significant value is less than 0.05, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This means that, partially, the independent variable has a significant effect on the dependent variable (Magdalena & Angela Krisanti, 2019).

2. N-Gain Test

The n-gain test is used to measure the effect produced by the program intervention (Oktavia & Prasasty, 2019)(Coletta & Steinert, 2020)(Navarrete et al., 2024)(Christman et al., 2024). In this study, the n-gain test is used to determine the extent of learning improvement in both the control and experimental classes that used the developed LMS.

Table 2. N-Gain Test Criteria

Gain Value	Description
$G \geq 0.7$	High
$0.7 > G \geq 0.3$	Moderate
$G < 0.3$	Low

Source: Wahab et.all, 2021

RESULTS AND DISCUSSION

Research Result

To assess the impact of the LMS on students learning outcomes, reflecting their cognitive competence, a test instrument was developed to measure these abilities. The test items created for research purposes must meet specific criteria. This is necessary to ensure that the test is not designed arbitrarily. A test must be validated to meet certain standards. The test also needs to align with the success indicators that have been defined. It is important to note that the learning elements used in this study focus on Light Vehicle Engine Systems. The targeted learning outcomes for the students are as follows: By the end of phase F, students should be able to

perform maintenance and overhaul (disassembly, inspection, repair, and installation) on the Engine Management System (EMS). The core subject of this study is Electronic Fuel Injection (EFI), and the learning objectives are: 1) Students can analyze the differences between the Electronic Fuel Injection (EFI) system and conventional systems based on their working principles. 2) Students can analyze the relationships between EFI components to support the combustion process in the engine. 3) Students can explain the working process of the EFI system based on the input and output of the involved sensors. 4) Students can analyze the steps in EFI system maintenance to identify the causes of damage or malfunction. If students achieve a score above the Learning Goal Achievement Criteria (LGAC), it indicates that they have mastered the cognitive competencies for this material. Learning is considered successful if 75% of students master the material and achieve evaluation results above the LGAC or Learning Goal Achievement Criteria (Lestari, 2019)(Winget & Persky, 2022)(Pelánek & Řihák, 2018).

When a pretest was administered to the experimental class, the average score was 52.08, which is far below the LGAC. None of the 32 students scored above 75. This result is far from the success criteria for learning. Cognitively, the students could not be considered competent. After the treatment, which involved learning through the developed LMS, the average score increased to 85.31, with 84.38% of students achieving the LGAC. Based on these results, it can be concluded that the learning was successful. The obtained scores also indicate that the students have mastered the cognitive competencies in EFI system maintenance.

Discussion

The main goal of this research process is to determine whether there is an impact of the developed LMS on students learning outcomes in the experimental class. The model used was a pretest-posttest design. Data analysis tests were conducted to test the hypothesis, compare two or more samples, and determine the relationship between two or more variables. There are several types of t-tests, including the independent t-test and paired t-test. The independent t-test is used for comparing two different groups, while the paired t-test is used for a single group. A significant difference is indicated when the significance value is less than 0.05. The results of the t-test analysis showed a value of $0.00 < 0.05$, meaning there was a significant difference between the posttest results of the experimental class and the control class.

To ensure the impact of the LMS on students cognitive competence, an n-gain test was also conducted to measure improvement. The results of the n-gain test for the experimental class using the LMS showed a value of 0.7022, which falls into the category of high improvement. In contrast, the control class scored 0.4863, placing it in the moderate improvement category (Nurrokhman et al., 2024). From both n-gain tests conducted in the control and experimental classes, it can be concluded that learning through the developed LMS has a greater impact on students cognitive competence compared to learning without the developed LMS.

CONCLUSION

This study aimed to examine the impact of the developed Learning Management System (LMS) on students cognitive competencies in the Electronic Fuel Injection (EFI) subject. Using a pretest-posttest design, the research compared two classes: the experimental class using the developed LMS and the control class that did not use the LMS. The results indicate that the application of the LMS significantly improved students cognitive abilities. The average pretest score in the experimental class was 52.08, with none of the students meeting the Learning Goal Achievement Criteria (LGAC) of ≥ 75. However, after the LMS-based treatment, the posttest average rose sharply to 85.31, with 84.38% of students achieving or exceeding the LGAC, indicating that the learning was successful and the students had mastered the targeted cognitive competencies.

The statistical analysis, using both independent and paired t-tests, revealed a significance of $p < 0.05$, suggesting a significant difference between the posttest scores of the experimental and control classes. Furthermore, the n-gain results showed a high improvement

category for the experimental class with a score of 0.7022, while the control class only showed moderate improvement with a score of 0.4863. These findings highlight that the LMS fosters interactive learning, enhances the presentation of material based on EFI component principles, and provides continuous evaluation, which helps improve students understanding and analytical abilities more effectively than conventional methods. Therefore, it is recommended to implement the developed LMS widely in automotive subjects such as motorcycle lighting systems and to conduct further research exploring variables like learning motivation and long-term effectiveness to strengthen the generalization of these findings.

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