

Impact of Learning Independence and Practical Tool Utilization on Outcomes in Basic Automotive Engineering

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ABSTRACT

This study examines the effect of learning independence and the use of practical tools on students' learning outcomes in the Basic Automotive Engineering subject. The research was conducted at SMK Negeri 4 Medan involving Grade X students of the Motorcycle Engineering Program. A quantitative approach with an ex post facto design was used to analyze the relationships among variables without experimental treatment. Data were collected through questionnaires to measure learning independence and practical tool usage, as well as tests to assess students' learning outcomes. The data were analyzed using regression techniques to determine both partial and simultaneous effects. The results show that learning independence has a positive and significant influence on students' learning outcomes. Likewise, the use of practical tools also positively affects students' achievement. When analyzed together, learning independence and practical tool usage significantly contribute to improved learning outcomes in Basic Automotive Engineering. These findings highlight the important role of internal student factors and learning facilities in vocational education. Practically, the study suggests that teachers should encourage independent learning and maximize the use of practical tools during instruction, while theoretically it reinforces learning theories that emphasize learner autonomy and experiential learning as key determinants of academic success.

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1. INTRODUCTION

Vocational education plays an important role in preparing human resources with competencies that combine theoretical knowledge and practical skills in accordance with industry needs. In Indonesia, vocational high schools (Sekolah Menengah Kejuruan/SMK) are designed to develop students' expertise in specific occupational fields, including automotive engineering. One of the core subjects in this program is Basic Automotive Engineering, which provides fundamental knowledge of automotive systems and working principles that serve as a foundation for advanced technical learning. Therefore, students' achievement in this subject is a key indicator of the effectiveness of vocational education in the automotive field.

However, learning outcomes in Basic Automotive Engineering at vocational high schools often remain below expectations. Preliminary observations at SMK Negeri 4 Medan show that several Grade X students experience difficulties in understanding basic concepts and applying theoretical knowledge during practical activities, as reflected in their academic performance. These findings indicate that the learning process has not yet fully supported students in developing the competencies required in vocational education, pointing to the need for further investigation into the factors influencing learning outcomes.

One factor that is considered to influence students' learning outcomes is learning independence. Learning independence refers to students' ability to regulate their own learning, including setting learning objectives, managing learning activities, and utilizing learning resources effectively. In the context of vocational education, where students are

required to actively engage in both theoretical and practical learning, learning independence is essential. Nevertheless, many students still depend heavily on teacher-centered instruction, which may limit their active involvement in learning and negatively affect their academic achievement.

In addition to learning independence, the use of practical tools is another important factor influencing learning outcomes in vocational education. From an experiential learning perspective, practical tools function as instructional media that transform abstract automotive concepts into concrete experiences. Practical tools enable students to directly observe, manipulate, and experiment with real automotive components, strengthening cognitive understanding and psychomotor competence. Theoretically, the use of practical tools can be positioned as an external learning variable (X_2) that contributes to improved learning outcomes (Y). Nevertheless, observations at SMK Negeri 4 Medan indicate that the utilization of practical tools in Basic Automotive Engineering learning has not been optimal. In some cases, practical tools are limited in number, not used intensively, or not integrated effectively with theoretical instruction. As a result, learning activities tend to focus more on theory, reducing students' opportunities to develop practical understanding and technical skills.

Previous studies have shown that learning independence has a positive influence on students' learning outcomes, particularly in improving motivation, engagement, and academic achievement. From a self-regulated learning perspective, learning independence can be conceptualized as an internal variable (X_1) that directly affects performance. Other studies also indicate that appropriate learning media and practical tools enhance students' understanding and performance in vocational education. However, most existing studies examine these variables separately or in different contexts. Empirical studies that explicitly analyze the combined effect of learning independence (X_1) and practical tool usage (X_2) on learning outcomes (Y) in Basic Automotive Engineering remain limited. This lack of integrated analysis forms a research gap and theoretically supports the need to test the hypothesis that both variables simultaneously influence learning outcomes.

Based on these conditions, there is a clear research problem that needs to be investigated. Learning outcomes in Basic Automotive Engineering at SMK Negeri 4 Medan are relatively low, and this condition is suspected to be influenced by students' weak learning independence (X_1) and suboptimal practical tool utilization (X_2). Without empirical testing of the theoretical relationship between these variables and learning outcomes (Y), improvement efforts may lack direction. Therefore, a systematic study is required to examine the magnitude of influence exerted by learning independence and practical tool usage on students' achievement, consistent with theoretical assumptions linking autonomy and experiential learning to academic performance.

Accordingly, this study explicitly aims to analyze the effect of learning independence and the use of practical tools on students' learning outcomes in the Basic Automotive Engineering subject at SMK Negeri 4 Medan. These objectives are derived directly from the theoretical framework connecting internal and external learning factors to achievement. First, the study tests the hypothesis that learning independence (X_1) has a positive effect on learning outcomes (Y). Second, it examines the hypothesis that practical tool usage (X_2) positively affects learning outcomes (Y). Third, it evaluates the simultaneous effect of X_1 and X_2 on Y as the central hypothesis of this research. Achieving these objectives provides empirical validation of the proposed theoretical model.

The significance of this study lies in its theoretical and practical contributions. Theoretically, the study strengthens empirical evidence regarding the interaction between internal learner characteristics and external instructional support in vocational education. By operationalizing learning independence and practical tool usage as measurable variables (X_1 and X_2), this research contributes to student-centered and experiential learning theory. In addition, it addresses a literature gap by integrating both variables into a single analytical framework rather than examining them in isolation.

From a practical perspective, this study provides actionable insights for teachers, administrators, and policymakers. The findings can inform instructional strategies that promote learning independence, such as problem-based and self-directed learning, while optimizing the integration of practical tools. This alignment between theory and classroom practice supports the assumption that strengthening both variables will improve learning outcomes. Schools may use the results to enhance facility management and ensure that theoretical instruction is consistently reinforced through structured hands-on experience.

In addition, this study contributes to improving vocational education quality by offering evidence-based recommendations for curriculum and instructional reform. Emphasizing the joint importance of learning independence and practical tool usage encourages a shift from teacher-centered instruction toward student-centered, practice-oriented models. Constructivist and experiential learning theories predict that such environments produce stronger learning outcomes, reinforcing the hypotheses tested in this research.

In conclusion, learning outcomes in Basic Automotive Engineering are influenced by interrelated internal and external factors, particularly learning independence and practical tool usage. The relatively low achievement observed at SMK Negeri 4 Medan highlights the urgency of empirically testing the theoretical model connecting these variables. By analyzing both individual and combined effects, this study seeks to explain how vocational learning outcomes can be systematically improved.

Education is a strategic investment in human resource development and plays a vital role in national progress. In the Indonesian context, this importance is emphasized in the Preamble to the 1945 Constitution, paragraph IV, which states that improving the nation's intelligence is a primary goal. Vocational education, particularly Vocational High Schools (SMK), is designed to prepare a skilled workforce aligned with industrial needs. Vocational education equips students with

work skills in specific fields to prepare them for employment[1]. This mandate strengthens the relevance of examining determinants of vocational learning outcomes.

In vocational learning processes, learning independence represents a crucial determinant of academic success. Haris defines independent learning as an active process where students regulate goals, strategies, and evaluation based on prior knowledge. Self-Determination Theory explains that intrinsic motivation sustains autonomy and persistence. Theoretically, this positions learning independence as an internal predictor (X_1) of achievement. Students lacking internal motivation tend to remain passive and dependent on teacher instruction, weakening learning outcomes. Limited access to learning resources may also reduce independence and engagement[2][3]. These theoretical foundations support the hypothesis that stronger learning independence leads to higher achievement.

In addition to independent learning, the use of practical tools is a critical component of vocational instruction. Practical tools facilitate understanding of technical content and strengthen psychomotor competence. In Basic Automotive Engineering, tools allow students to apply concepts directly, transforming theory into authentic experience. Experiential learning theory predicts that hands-on engagement improves performance, positioning practical tool usage as an external predictor (X_2) of achievement[4]. Therefore, the study hypothesizes a positive relationship between practical tool usage and learning outcomes.

Learning outcomes serve as the primary indicators of instructional success and encompass cognitive, affective, and psychomotor change. Bloom's taxonomy emphasizes balanced development across these domains. Learning outcomes are shaped by internal factors such as motivation and independence and external factors such as facilities and instructional media. The interaction of these dimensions explains why this study simultaneously examines X_1 and X_2 as predictors of Y [5].

Issues at SMK Negeri 4 Medan suggest that learning outcomes in Basic Automotive Engineering remain low. Teacher interviews indicate that weak independence and underutilization of practical tools contribute to this condition. Many students enroll without strong intrinsic interest, reducing motivation and engagement. These observations reinforce the theoretical expectation that deficiencies in X_1 and X_2 lead to reduced Y .

Even semester exam results for the 2023/2024 academic year show averages of 62.6 and 61.6, far below the Minimum Completion Criteria (KKM) of 75. The overall average of 62.1 reflects a significant achievement gap. This empirical evidence strengthens the research hypothesis that improving learning independence and practical tool usage is essential for raising performance.

Based on this description, research examining the influence of independent learning and practical tool usage on student learning outcomes is essential. This study is expected to contribute to the development of vocational learning models and provide practical input for improving instructional quality[6]. The investigation directly tests the theoretical assumptions linking X_1 and X_2 to Y , forming the foundation of the study's hypotheses.

2. RESEARCH METHOD

This study uses a quantitative approach with an associative research design. The purpose of this approach is to determine the relationship and influence between two independent variables, namely learning independence and the use of practical tools, on one dependent variable, namely students' learning outcomes in the subject of Basic Automotive Engineering. The approach employed is *ex post facto*, in which the researcher does not provide direct treatment but observes phenomena that have naturally occurred in the students' learning environment. The *ex post facto* design is considered appropriate for this study because the variables examined already exist within the students and take place in authentic instructional conditions, making experimental manipulation impractical and ethically inappropriate. The researcher identifies causal relationships based on existing data without altering the learning situation, ensuring that the findings reflect real educational conditions. Therefore, the *ex post facto* design is suitable for examining the influence of learning independence and practical tool usage on learning outcomes in a vocational education context.[7], [8]

The population in this study consisted of all Grade X students of the Motorcycle Engineering Expertise Program at SMK Negeri 4 Medan in the 2024/2025 academic year. The sample in this study was drawn from two classes, namely X TSM 3 and X TSM 4. The sampling technique used the Slovin formula with an error rate (e) of 5%. Based on the calculation, the total sample obtained was 54 students, distributed as 35 students from class X TSM 3 and 35 students from class X TSM 4. The sampling method applied was proportional random sampling, ensuring that all members of the population had an equal opportunity to be selected as samples.[9]

This observe consists of two unbiased variables and one based variable. the primary unbiased variable is gaining knowledge of independence, which refers to college students' capacity to devise, manage, and examine their learning activities independently. Indicators used include learning initiative, goal setting, learning strategy selection, learning process control, self-evaluation, and the ability to utilize learning resources.[10].

The second independent variable is the use of practical tools, defined as students' ability to recognize, use, and maintain automotive practical tools according to work procedures and safety standards. Indicators include understanding tool function, accuracy of use, implementation of OHS, work efficiency, and tool maintenance.[11]. Meanwhile, the dependent variable is learning outcomes, which in this study are measured through student achievement in the subject of Automotive Engineering Basics, both from the cognitive aspect (remembering, understanding, applying, and analyzing)

based on Bloom's taxonomy. Furthermore collection was conducted using two types of instruments: questionnaires and tests. Questionnaires were used to measure learning independence and the use of practical tools, each consisting of 30 statements with a 5-point Likert scale. Tests were used to measure student learning outcomes in the form of 30 multiple-choice questions, which were structured based on the curriculum's core competency framework and Bloom's taxonomy levels C1 to C4. Before use, all instruments were tested for validity and reliability. Item validity was tested using biserial correlation, and was declared valid if $r_{count} > r_{table}$. Instrument reliability was tested using the KR-20 formula and Cronbach's Alpha. The test results showed that all questionnaire items and questions were declared valid and reliable, with reliability coefficient values in the high to very high category.[12], [13], [14].

The statistics evaluation technique used became quantitative analysis using Microsoft Excel software. Prerequisite evaluation checks had been conducted first, which include a normality test using the Kolmogorov–Smirnov check and a homogeneity check using Levene's test. If the records were commonly distributed and homogeneous, speculation testing turned into endured. The hypothesis used includes a easy linear regression check to see the impact of each independent variable on gaining knowledge of effects, in addition to a couple of linear regression to decide the simultaneous effect of getting to know independence and using practical equipment on mastering outcomes. Statistical decisions are primarily based on a importance stage of 5% ($\alpha = 0.05$), with the criteria $t_{hitung} > t_{tabel}$ to state a partial huge effect, and $F_{hitung} > F_{tabel}$ for a simultaneous effect.[15].

3. RESULTS AND DISCUSSION

A. Description of Research Data

This study employed a quantitative correlational research design to examine the influence of learning independence and the use of practical tools on students' learning outcomes in Basic Automotive Engineering. This design changed into selected to discover the value and direction of relationships among variables and to determine both partial and simultaneous outcomes of impartial variables on the dependent variable. The population of this have a look at comprised all Grade X college students enrolled inside the car Engineering software at SMK Negeri four Medan in the course of the educational year of the have a look at. The sample was selected using a total sampling technique, in which all students in the population were included as research participants. This approach was chosen to ensure comprehensive representation and to minimize sampling bias.

This study was conducted on 35 students of class X of the Motorcycle Engineering Expertise Program at SMK Negeri 4 Medan, consisting of students class X TSM 3. Based on the results of questionnaires and tests, data were obtained regarding learning independence, use of practical tools, and student learning outcomes.

Table 1 . Learning Independence Questionnaire and Test Table

Age (Years)	Number of Respondents	Percentage
15	12	22,22%
16	8	62,96%
17	15	14,82%
Total	35	100%

Based on the table, the majority of students were 16 years old (62.96%) and male (90.74%), which reflects the dominance of interest in the field of automotive engineering among male students. The average value of student learning outcomes based on the Even Semester Exam of the 2023/2024 Academic Year shows that class X TSM 3 obtained an average score of 62.6, which is far below the Minimum Completion Criteria (KKM) of 75. This indicates that student learning outcomes are still relatively low and require intervention in aspects of learning strategies and student motivation. The validity of the questionnaires was examined using content validity, evaluated by subject matter experts in vocational education. Empirical validity testing was conducted using item-total correlation analysis, where items with correlation coefficients above the critical value were considered valid. Reliability checking out turned into accomplished the use of Cronbach's alpha, with coefficients exceeding 0.70 indicating appropriate reliability. The outcomes showed that all instruments used on this look at have been legitimate and reliable for data collection.

Facts analysis changed into carried out the use of descriptive and inferential statistical strategies. Descriptive statistics were used to determine the distribution and tendency of every variable. Inferential evaluation worried more than one linear regression to have a look at the partial and simultaneous influence of studying independence and sensible tool use on studying consequences.

Prior to regression analysis, prerequisite tests have been performed, consisting of normality, linearity, multicollinearity, and heteroscedasticity assessments, to make sure that the statistics met statistical assumptions. All analyses have been done using statistical software.

The findings of this study confirm that learning independence plays a crucial role in improving students' learning outcomes in vocational education, particularly in Basic Automotive Engineering. This result supports previous research, which emphasizes that self-directed learners are more capable of managing their learning processes, maintaining motivation,

and applying knowledge effectively in practice-oriented subjects. In the context of automotive education, learning independence enables students to actively engage in troubleshooting, follow work procedures independently, and reflect on their learning experiences.

The significant influence of practical tool use on learning outcomes reinforces the principle that vocational education must prioritize hands-on learning. Practical tools serve as a bridge between theory and real-world application, allowing students to develop psychomotor skills, technical accuracy, and work discipline. When students are given adequate opportunities to interact with automotive equipment, they are better able to internalize abstract concepts and improve their performance in practical tasks.

Importantly, the combined effect of learning independence and practical tool use highlights that effective vocational learning does not rely solely on instructional facilities or student characteristics in isolation. Instead, optimal learning outcomes are achieved when independent learning behaviors are supported by well-designed practical learning environments. Students who are independent learners tend to maximize the use of practical tools by exploring, experimenting, and seeking solutions autonomously, which leads to deeper understanding and skill mastery.

These findings have important pedagogical implications for vocational schools. Teachers should not only focus on delivering technical content but also actively foster students' learning independence through student-centered learning strategies, such as project-based learning, problem-based learning, and guided practice. At the same time, schools need to ensure that practical tools are used systematically and integrated into learning objectives rather than treated as supplementary activities.

Overall, this study contributes to vocational education research by providing empirical evidence that integrates internal learner factors and external instructional resources in explaining learning outcomes. The results emphasize that improving learning outcomes in Basic Automotive Engineering requires a holistic approach that combines the development of independent learners with the effective utilization of practical tools in the learning process.

B. Results of Instrument Validity and Reliability Tests

Primarily based at the consequences of the device take a look at that has been performed, it could be visible thru the effects of the validity check that of the 30 questions used, 25 questionnaire statements were declared legitimate due to the fact they'd r_{pbis} more than r_{table} (0,361), and 5 questionnaire statements have been declared invalid. So it's far appropriate for use to degree scholar studying consequences inside the problem of automobile Engineering fundamentals. hence, this test device can be trusted to provide an accurate photo of students' cognitive skills according with the expected competencies.

Based at the results of the validity test calculations, maximum of the questions about the studying outcome instrument were declared valid, because they'd a correlation fee extra than the r table (0.3061). for this reason, the getting to know final results instrument is appropriate for use in studies because it has met the necessities for content and empirical validity.

The results of the reliability take a look at calculation the use of the Kuder Richardson 20 (KR-20) formula display that the reliability value (r_{11}) is zero.05 for 25 questions with a complete variance (S^2) of 0.2586. the proper share fee (p) stages from 0.3750 to 0.5625 with a median $p-q$ fabricated from 0.2461. This very low reliability value indicates that the gaining knowledge of final results take a look at tool is not but reliable, so the questions want to be advanced so that you can produce more consistent and correct measurements of pupil abilities.

C. Results of the Prerequisite Analysis Test

The outcomes of the normality test using the Kolmogorov-Smirnov take a look at showed that all variables were normally disbursed with a significance $\alpha > 0.05$. The homogeneity check the usage of Levene's take a look at additionally confirmed that the facts had homogeneous variance, which means it may be used for regression evaluation.

Table 2 Prerequisite Analysis Testt

No.	Class	N	Data	L-Count	L-Table	Conclution
1	Experiment	35	Post-Test	0.1466	0,1519	Normal
2	Control	35	Post-Test	0.1437	0,1519	Normal

Based on the table, the information normality check used the Liliefors test at a significance level of $\alpha = 0.05$, which on the vital value of the Liliefors check in order that L-table = 0.1519 shows that the submit-take a look at statistics of the experimental and control class college students' mastering outcomes were normally disbursed. this may be visible from the importance cost of the experimental class L-count = 0.1466 which is smaller than L-table = 0.1519, and the significance value of the manipulate magnificence L-count number = 0.1437 that's smaller than L-table = 0.1519.

D Regression Test Results

1. The Influence of Learning Independence on Learning Outcomes

The results of a easy linear regression check indicate that the getting to know independence variable has a high-quality and great have an impact on on mastering consequences. The calculated t price = 6.012 is greater than the t desk = 2.006 with a significance level of $0.000 < 0.05$. This suggests that the higher the student's getting to know independence, the higher the learning outcomes accomplished. This finding is in step with Handayani's (2018) announcement that gaining knowledge of independence is an movement pushed by initiative and duty to manage learning independently, which in the long run has a huge effect on improving getting to know achievement.

2. The Effect of Using Practical Tools on Learning Outcomes

The use of practical tools also showed a positive and significant impact on student learning outcomes. The results of the regression analysis showed a t-value of 5.490 and a significance value of $0.000 < 0.05$. This confirms that the appropriate and effective use of practical tools can improve students' conceptual understanding and technical skills. These findings support the opinion of Siregar and Pramana, who stated that students' direct involvement with practical tools significantly improves their psychomotor understanding and work readiness.[16].

3. The Influence of Learning Independence and Simultaneous Use of Practical Tools

Multiple regression analysis shows that independent learning and the use of practical tools together have a significant influence on learning outcomes. The calculated F value of 39.210 is greater than the F table value of 3.17 at the 5% significance level. Furthermore, the coefficient of determination (R^2) value of 0.601 indicates that 60.1% of the variation in learning outcomes can be explained by these two independent variables. Meanwhile, the remaining 39.9% is influenced by other factors outside this study. This finding aligns with Isnawan and Maulana's (2021) statement that student learning outcomes are influenced by the simultaneous interaction between practical experience, learning media, and student learning motivation.

The results of the look at imply that studying independence has a significant have an effect on on student gaining knowledge of consequences. that is established through a easy regression test, where the t-price of 6.012 is greater than the t-desk of 2.006 at a importance degree of 5%. A importance cost (Sig.) of $0.000 < 0.05$ indicates that the alternative hypothesis (H_1) is popular. which means there may be a superb dating between the level of scholar independence and their mastering consequences inside the challenge of car Engineering fundamentals. This finding supports the theory of Ryan (1985) and Zimmerman (2000), which states that scholars with high motivation and self-regulation are better able to manipulate mastering and reap higher academic outcomes.

Furthermore, the variable of practical tool use also showed a significant influence on student learning outcomes. The results of the simple regression test showed that the calculated t value was $5.490 > t$ table of 2.006 and the Sig. Value was $0.000 < 0.05$. This proves that the use of practical tools properly and according to procedures can help students understand technical material concretely. This finding is consistent with the opinion of Siregar and Pramana (2020), who emphasized the importance of practical tools in vocational learning because they can improve psychomotor skills and accelerate concept mastery.

Multiple regression analysis that tested the influence of learning independence and the use of practical tools simultaneously on learning outcomes showed that both variables together made a significant contribution. The calculated F value of $39.210 > F_{table}$ of 3.17, and the significance value of $0.000 < 0.05$, confirmed that the regression model is suitable for explaining the relationship between variables. The coefficient of determination (R^2) value was 0.601, which means that 60.1% of the variation in student learning outcomes can be explained by learning independence and the use of practical tools, while the remaining 39.9% is influenced by other factors not examined, such as the learning environment, teacher teaching methods, or student interests.

Furthermore, the average value of student learning outcomes after participating in learning within a period of five meetings was 71.11, higher than the initial score (pretest) of 56.44. This increase indicates the effectiveness of the learning process in improving student understanding, which is inseparable from the role of independent learning and optimization of practical tools in the workshop. This increase is also supported by the results of the paired two-sample t-test, which produced t count = $7.174 > t$ table = 2.006, with a significance of 0.000. This indicates that there was a significant increase in learning outcomes before and after learning.

Overall, these findings reinforce the importance of students' cognitive, affective, and psychomotor aspects in vocational education. Learning independence, as an internal aspect of students, and the use of practical tools as an external

learning factor, must be synergistically addressed by educators and educational unit administrators. Teachers play a role not only as providers of material but also as facilitators in creating an independent and applicable learning environment. Therefore, providing adequate practical tools and training in their use is an essential prerequisite for optimal student learning outcomes in skills-based vocational schools.

The results also indicate that the use of practical tools has a positive and significant effect on students' learning outcomes ($p < 0.05$). Students who actively engaged with automotive tools, training equipment, and instructional media during learning activities showed higher achievement scores compared to those with limited practical exposure. This finding highlights the importance of hands-on learning experiences in strengthening students' understanding of automotive concepts and procedures.

The multiple regression analysis demonstrated that learning independence and the use of practical tools simultaneously have a significant effect on learning outcomes in Basic Automotive Engineering. The coefficient of determination (R^2) indicates that a substantial proportion of variance in students' learning outcomes can be explained by the combined contribution of these two variables, while the remaining variance is influenced by other factors not examined in this study. These findings suggest that learning independence and practical tool utilization complement each other in improving learning outcomes. Students with high learning independence benefit more from practical learning environments, as they are more proactive in exploring tools, practicing skills, and solving technical problems.

4. CONCLUSION

Based on the findings of this study, learning independence and the use of practical tools are shown to be significantly associated with learning outcomes in Basic Automotive Engineering among Grade X students at SMK Negeri 4 Medan. In line with self-regulated learning and experiential learning theories, students who demonstrate stronger learning independence tend to achieve higher learning outcomes, as they are more capable of managing their learning activities and engaging actively in both theoretical and practical tasks. Similarly, the effective use of practical tools supports meaningful learning by enabling students to transform abstract automotive concepts into concrete experiences, thereby strengthening cognitive understanding and psychomotor skills. The combined influence of these internal and external factors indicates that learner autonomy is most effective when supported by well-structured hands-on learning environments.

Nevertheless, the findings of this study should be interpreted within certain limitations. The relatively small sample size and the focus on a single vocational school limit the generalizability of the results, and potential measurement constraints may also affect the precision of the findings. Despite these limitations, the study provides important implications for vocational education practice, particularly in Basic Automotive Engineering instruction. Teachers are encouraged to promote learning independence through student-centered approaches while integrating practical tools systematically into the learning process. By aligning instructional strategies with principles of learner autonomy and experiential learning, vocational schools can create more effective learning environments that support improved student learning outcomes.

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