LEARNING : Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran
Vol. 6, No. 4, September-November 2026
e-ISSN : 2777-0575 | p-ISSN : 2777-0583
Online Journal System : https://jurnalp4i.com/index.php/learning

PROBLEM-BASED LEARNING MODEL TO IMPLEMENT DEEP LEARNING IN SHIP MACHINING PRACTICE

Syarifuddin Ahmad[1], Mustamid[2], Nur Izzati[3], Desi Rahmatina[4]
Magister Pedagogi Universitas Maritim Raja Ali Haji[1,2,3,4]
e-mail: syarifuddinahmadz@gmail.com[1], mustamid49@yahoo.com[2], nurizzati@umrah.ac.id[3], desirahmatina@umrah.ac.id[4]

Diterima: *24/06/2026*; Direvisi: *04/09/2026*; Diterbitkan: *13/09/2026*

ABSTRAK

Pembelajaran praktik permesinan kapal di sekolah menengah kejuruan menuntut keterlibatan aktif siswa, kemampuan menganalisis permasalahan teknis, serta penguasaan keterampilan yang sesuai dengan situasi kerja nyata. Namun, proses pembelajaran yang masih didominasi arahan guru berpotensi membatasi partisipasi siswa dalam mengeksplorasi masalah dan menentukan solusi secara mandiri. Penelitian ini bertujuan menganalisis pengaruh penerapan *Problem-Based Learning* (PBL) dalam pembelajaran mendalam terhadap keterlibatan siswa, kemampuan pemecahan masalah, dan hasil belajar praktik permesinan kapal siswa kelas XI di SMK Negeri 5 Tanjungpinang. Penelitian menggunakan pendekatan kuantitatif dengan metode kuasi eksperimen melalui desain *pretest-posttest control group*. Sampel terdiri atas dua kelas yang dipilih secara purposif, yaitu kelas eksperimen yang memperoleh pembelajaran berbasis masalah dan kelas kontrol yang mengikuti pembelajaran konvensional. Pengumpulan data dilakukan melalui observasi, angket, tes, dan dokumentasi, sedangkan analisis mencakup statistik deskriptif, uji prasyarat, *independent samples t-test*, dan *N-Gain*. Hasil penelitian menunjukkan bahwa kelas eksperimen memperoleh capaian lebih tinggi dibandingkan kelas kontrol pada keterlibatan belajar, kemampuan pemecahan masalah, dan hasil belajar praktik. Perbedaan hasil belajar terbukti signifikan dengan nilai signifikansi 0,000 < 0,05, sementara nilai *N-Gain* kelas eksperimen sebesar 0,72 berada pada kategori tinggi. Temuan ini menegaskan bahwa PBL dapat menjadi strategi pembelajaran kontekstual untuk memperkuat keterlibatan, kemampuan pemecahan masalah, dan kompetensi praktik siswa pendidikan vokasi.
Kata Kunci: *Deep Learning, Problem-Based Learning, Keterlibatan Siswa, Kemampuan Pemecahan Masalah, Permesinan Kapal.*

ABSTRACT

Practical ship machinery learning in vocational high schools requires students' active engagement, the ability to analyze technical problems, and the mastery of skills relevant to real workplace situations. However, learning processes that remain dominated by teacher instruction may limit students' opportunities to explore problems and determine solutions independently. This study aimed to analyze the effect of implementing *Problem-Based Learning* (PBL) within a deep learning approach on student engagement, problem-solving skills, and practical learning outcomes among eleventh-grade students in the Ship Machinery Program at SMK Negeri 5 Tanjungpinang. The study employed a quantitative approach using a quasi-experimental method with a *pretest-posttest control group* design. The sample consisted of two purposively selected classes: an experimental class receiving problem-based instruction and a control class receiving conventional instruction. Data were collected through observation,

https://doi.org/10.51878/learning.v6i4.13089

questionnaires, tests, and documentation, and analyzed using descriptive statistics, prerequisite tests, an *independent samples t-test*, and *N-Gain* analysis. The findings revealed that the experimental class achieved higher scores than the control class in student engagement, problem-solving skills, and practical learning outcomes. The difference in learning outcomes was statistically significant, with a significance value of 0.000 < 0.05, while the experimental class obtained an *N-Gain* score of 0.72, categorized as high. These findings indicate that PBL can serve as a contextual learning strategy to strengthen student engagement, problem-solving skills, and practical competencies in vocational education.
Keywords: *Deep Learning, Problem-Based Learning, Student Engagement, Problem-Solving Skills, Ship Machinery.*

INTRODUCTION

Vocational education occupies a strategic position in preparing human resources who are technically competent, adaptable, and capable of responding to increasingly complex workplace demands. The transformation of industry, technological development, and the growing need for twenty-first-century competencies require vocational students to develop not only technical knowledge but also critical thinking, collaboration, creativity, and problem-solving abilities. In the Indonesian context, these demands are increasingly relevant to the implementation of the *Merdeka Curriculum*, which emphasizes the development of competencies that enable learners to respond to dynamic social and occupational challenges. Jaya et al. (2023) demonstrated that the implementation of twenty-first-century skills within the *Merdeka Curriculum* requires learning processes that provide students with opportunities to think, communicate, collaborate, and solve problems rather than merely receive information. Therefore, vocational learning needs to move beyond the transmission of procedural knowledge toward learning experiences that actively engage students in constructing, applying, and evaluating knowledge within meaningful contexts.

Despite these expectations, the implementation of vocational learning continues to face challenges related to student participation and the quality of learning experiences. Students may demonstrate adequate basic technical abilities while remaining dependent on teachers when confronted with unfamiliar problems that require independent analysis and decision-making. Student engagement is particularly important because active participation, interaction, and involvement in learning activities influence the quality of the learning process and students' opportunities to develop higher-order competencies. Zariayufa et al. (2022) showed that student engagement is influenced by the learning environment and the support received from significant educational actors, indicating that engagement cannot be separated from the design of the learning process itself. In practical vocational instruction, a learning environment that places students as active participants is therefore essential to encourage initiative, collaboration, responsibility, and sustained involvement during the completion of practical tasks.

These issues are relevant to ship machinery practical learning at SMK Negeri 5 Tanjungpinang, where students are expected to master technical procedures while also being able to diagnose and respond to problems encountered during practice. Preliminary observations indicated that some students experienced difficulties in identifying technical problems, determining appropriate solutions, and independently evaluating the results of their practical work. Such conditions suggest a gap between the expected characteristics of vocational graduates and the actual learning process, particularly when practical instruction remains dominated by teacher explanations and procedural demonstrations. The specificity of

https://doi.org/10.51878/learning.v6i4.13089

LEARNING : Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran
Vol. 6, No. 4, September-November 2026
e-ISSN : 2777-0575 | p-ISSN : 2777-0583
Online Journal System : https://jurnalp4i.com/index.php/learning

maritime vocational education further strengthens the need for contextual learning because competence in this field is closely associated with technical accuracy, operational procedures, and the ability to respond appropriately to real working conditions. Fadhilah et al. (2026), through the development of *STCW*-based thermodynamics teaching materials for ship engineering cadets, highlighted the importance of aligning maritime learning with competency requirements that are relevant to professional practice, while Pratama (2026) also emphasized the distinctive context of Indonesian maritime vocational education. Consequently, practical learning in ship machinery requires an instructional approach that connects conceptual understanding with authentic technical situations.

One instructional approach that is relevant to these needs is *Problem-Based Learning* (PBL), which organizes learning around meaningful problems that encourage students to investigate, discuss, formulate solutions, and evaluate the results of their actions. Rather than positioning students primarily as recipients of information, PBL creates opportunities for them to become active participants in the learning process. Evidence from vocational education supports this potential, as Saputra et al. (2025) found that the implementation of PBL contributed to improvements in students' interest in learning within automotive vocational competence. Similarly, Sari (2023) reported that problem-based instruction supported the development of problem-solving abilities among vocational high school students, while Laili et al. (2025), through a *systematic literature review*, identified the potential of PBL-based practical learning to strengthen students' critical thinking skills. More broadly, Anthony et al. (2025), in a meta-analysis of vocational education studies, demonstrated that PBL has a positive effect on students' critical thinking development, suggesting that problem-oriented learning may provide a meaningful pedagogical foundation for strengthening cognitive and practical competencies simultaneously.

The relevance of PBL can also be examined through the perspective of *deep learning*, which emphasizes meaningful understanding, active knowledge construction, reflection, and the application of knowledge in different situations. Within vocational education, *deep learning* should not be interpreted merely as the use of advanced technology, but as a learning orientation that encourages students to understand why and how knowledge can be applied to solve authentic problems. Arjaya et al. (2025) highlighted the growing importance of *deep learning* in vocational education through the development of instructional materials designed to support more meaningful and adaptive learning experiences. In addition, Siregar et al. (2025) demonstrated the relevance of integrating *deep learning* principles into problem-based instruction in vocational education, particularly in creating learning environments that encourage students to engage more actively with complex problems. These findings suggest that the integration of *deep learning* principles with PBL may provide a stronger pedagogical framework for vocational practice because students are encouraged not only to perform procedures but also to understand, analyze, and justify the solutions they produce.

However, the existing body of research still reveals several limitations. Studies on PBL in vocational education have frequently concentrated on a single outcome, such as learning interest, critical thinking, or problem-solving ability, whereas the interrelationship between student engagement, problem-solving skills, and practical learning outcomes has received less integrated attention. Some recent studies have also focused on particular subject areas, such as automotive competence, mathematics, electrical practice, or health vocational education, making it difficult to directly transfer their findings to the technical characteristics of maritime vocational practice (Laili et al., 2025; Saputra et al., 2025; Sari, 2023; Siregar et al., 2025).

https://doi.org/10.51878/learning.v6i4.13089

LEARNING : Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran
Vol. 6, No. 4, September-November 2026
e-ISSN : 2777-0575 | p-ISSN : 2777-0583
Online Journal System : https://jurnalp4i.com/index.php/learning

Moreover, although maritime vocational education requires learning that is closely connected to authentic technical and professional contexts, research examining the implementation of PBL within ship machinery practice remains limited. The available studies concerning maritime vocational learning, including Fadhilah et al. (2026) and Pratama (2026), underline the importance of contextualized maritime education but do not specifically examine how PBL influences student engagement, problem-solving skills, and practical learning outcomes simultaneously. Another relevant study by Englita et al. (2026) demonstrates that active learning models can contribute to the development of specific student competencies, yet its focus on *Project-Based Learning* and numeracy literacy among university students indicates a different instructional model, participant group, and outcome domain from the present investigation.

Based on these considerations, the present study offers novelty through the integrated examination of student engagement, problem-solving skills, and practical learning outcomes within the implementation of PBL informed by a *deep learning* orientation in ship machinery practice. The study focuses on eleventh-grade students at SMK Negeri 5 Tanjungpinang and positions the maritime vocational context as an important setting for examining how problem-based instruction can support meaningful practical learning. Unlike previous studies that primarily investigated isolated learning outcomes or were conducted in non-maritime vocational contexts, this study examines the simultaneous contribution of PBL to behavioral engagement, problem-solving competence, and practical achievement. Accordingly, this study aims to analyze the effect of the Problem-Based Learning model on students' learning engagement, problem-solving skills, and practical learning outcomes in ship machinery practice. The findings are expected to contribute to the development of contextual vocational pedagogy and provide empirical evidence for designing practical learning that is more active, meaningful, problem-oriented, and responsive to the competency demands of maritime vocational education.

METHOD

This study employed a quantitative approach using a quasi-experimental design to examine the effect of *Problem-Based Learning* (PBL) on student engagement, problem-solving skills, and practical learning outcomes in ship machinery practice. The research applied a *pretest-posttest control group design* involving an experimental class and a control class. The experimental class participated in learning activities organized according to the PBL stages, whereas the control class received conventional instruction. The research was conducted during the even semester of the 2025/2026 academic year at SMK Negeri 5 Tanjungpinang, involving eleventh-grade students enrolled in the Ship Machinery Vocational Program.

The participants were selected through purposive sampling based on the similarity of learning characteristics and their participation in the ship machinery practical course. Two classes, each consisting of 30 students, were assigned as the experimental and control groups, resulting in a total sample of 60 students. The independent variable was the implementation of the PBL model, while the dependent variables included student engagement, problem-solving skills, and practical learning outcomes. Data were obtained through classroom observations, student questionnaires, practical and written tests, and supporting documentation. The instruments were developed according to the competency indicators of ship machinery practice and were examined through expert judgment and empirical testing for validity, while their internal consistency was evaluated using *Cronbach's Alpha*.

https://doi.org/10.51878/learning.v6i4.13089

LEARNING : Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran
Vol. 6, No. 4, September-November 2026
e-ISSN : 2777-0575 | p-ISSN : 2777-0583
Online Journal System : https://jurnalp4i.com/index.php/learning

The research was conducted through preparation, implementation, and data analysis stages. During implementation, both groups completed a *pretest*, followed by the learning intervention in the experimental class and conventional instruction in the control class, after which a *posttest* and supporting measurements were administered. The collected data were analyzed descriptively using measures of central tendency and dispersion, followed by the *Kolmogorov-Smirnov* normality test and *Levene's test* for homogeneity. Differences between the two groups were examined using an *independent samples t-test* at a significance level of 0.05, while changes in practical learning outcomes were assessed using *N-Gain* analysis. All statistical procedures were performed using IBM SPSS Statistics version 26.

RESULT AND DISCUSSION

Result

Research Participants and Initial Learning Conditions

The study involved 60 eleventh-grade students enrolled in the Ship Machinery Vocational Program at SMK Negeri 5 Tanjungpinang. The participants were divided into an experimental class and a control class, with each group consisting of 30 students. The experimental class received learning through the *Problem-Based Learning* (PBL) model, whereas the control class participated in conventional learning activities. Before the intervention, both groups completed the initial measurement according to the research instruments, and the subsequent results were organized descriptively and inferentially to provide a systematic comparison between the two groups.

The descriptive findings were presented through tables showing student engagement, problem-solving skills, *pretest* and *posttest* scores, and *N-Gain* values. The statistical analysis was subsequently supported by prerequisite tests of normality and homogeneity before hypothesis testing was conducted. The presentation also includes a visual comparison of the *posttest* results to complement the numerical information shown in the tables. This arrangement allows the results to be presented through a combination of verbal descriptions, tables, and a figure without introducing interpretations that belong to the Discussion section.

Student Engagement

Student engagement was measured using questionnaire and observation data covering participation in learning activities, attention to practical tasks, cooperation during group work, and active involvement in completing assigned activities. The results were summarized using the number of participants, mean scores, and standard deviations for both research groups. Table 1 presents the descriptive comparison of student engagement between the experimental and control classes after the learning process. The table is intended to show the distribution of engagement scores without yet explaining the theoretical reasons underlying the observed differences.

Table 1. Student Engagement Data

Class	N	Mean	Standard Deviation
Experimental	30	84.26	5.14
Control	30	72.18	6.02

As shown in Table 1, the experimental class obtained a mean student engagement score of 84.26, whereas the control class obtained a mean score of 72.18. The standard deviations

https://doi.org/10.51878/learning.v6i4.13089

LEARNING : Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran
Vol. 6, No. 4, September-November 2026
e-ISSN : 2777-0575 | p-ISSN : 2777-0583
Online Journal System : https://jurnalp4i.com/index.php/learning

were 5.14 for the experimental class and 6.02 for the control class. The descriptive difference between the mean scores was 12.08 points, with the higher mean recorded in the experimental class. These results provide a descriptive overview of the student engagement data for the two groups.

Problem-Solving Skills

Problem-solving skills were assessed through practical tasks and essay-based questions administered to the participating students. The assessment focused on students' ability to identify technical problems, determine relevant solution procedures, apply appropriate work steps, and evaluate the results of practical problem-solving. Table 2 presents the descriptive results for problem-solving skills in both the experimental and control classes. The information includes the number of students, mean scores, and standard deviations for each group.

Table 2. Problem-Solving Skills Data

Class	N	Mean	Standard Deviation
Experimental	30	82.47	5.33
Control	30	70.25	6.11

Based on Table 2, the experimental class obtained a mean problem-solving score of 82.47, while the control class obtained a mean score of 70.25. The standard deviation of the experimental class was 5.33, compared with 6.11 in the control class. The difference between the two mean scores was 12.22 points, with the experimental class recording the higher descriptive score. The results in Table 2 therefore present the comparative distribution of problem-solving skills between the two research groups.

Practical Learning Outcomes

Practical learning outcomes were measured through *pretest* and *posttest* scores related to the ship machinery practice material. The *pretest* was used to describe the students' initial learning performance before the instructional treatment, whereas the *posttest* was administered after the learning activities had been completed. Table 3 presents the mean *pretest* and *posttest* scores for the experimental and control classes. The comparison between the two measurements provides an overview of changes in learning outcomes within each group.

Table 3. Mean Pretest and Posttest Scores

Class	Pretest	Posttest
Experimental	61.40	86.20
Control	60.85	74.12

As presented in Table 3, the experimental class recorded a mean *pretest* score of 61.40 and a mean *posttest* score of 86.20. The control class recorded a mean *pretest* score of 60.85 and a mean *posttest* score of 74.12. The difference between the initial mean scores was 0.55 points, whereas the difference between the *posttest* mean scores was 12.08 points. Thus, Table 3 describes the changes in practical learning outcome scores observed in both groups.

https://doi.org/10.51878/learning.v6i4.13089

LEARNING : Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran
Vol. 6, No. 4, September-November 2026
e-ISSN : 2777-0575 | p-ISSN : 2777-0583
Online Journal System : https://jurnalp4i.com/index.php/learning

Visual Comparison of Posttest Scores

To complement the numerical information in Table 3, the *posttest* results were also presented visually in Figure 1. The figure displays the mean *posttest* scores of the experimental and control classes using the same data reported in Table 3. The visual presentation makes the numerical difference between the two groups easier to identify. Figure 1 is therefore used as a supporting representation and does not replace the detailed numerical information presented in the table.

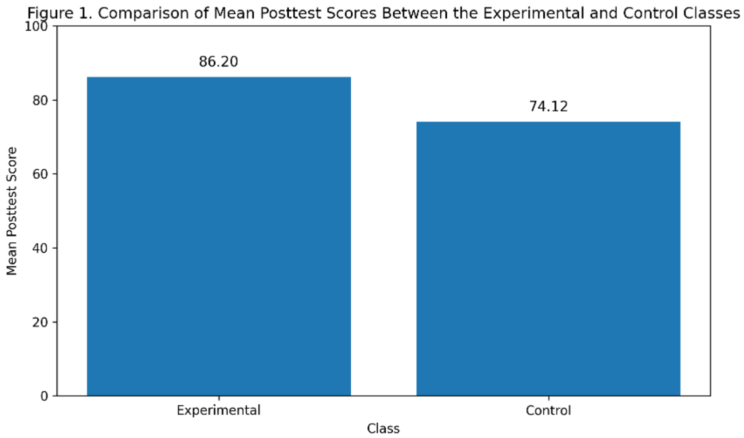

Figure 1. Comparison of Mean Posttest Scores Between the Experimental and Control Classes

As illustrated in Figure 1, the mean *posttest* score of the experimental class was 86.20, while the control class obtained a mean score of 74.12. The visual difference corresponds to the numerical results previously presented in Table 3. The experimental class recorded the higher mean *posttest* score among the two groups. Figure 1 therefore provides a graphical representation of the comparative *posttest* results without adding further causal interpretation.

N-Gain Analysis

The improvement in practical learning outcomes was further described using *N-Gain* analysis based on the difference between the *pretest* and *posttest* scores. The analysis was conducted for both the experimental and control classes to describe the magnitude of score improvement during the study. Table 4 presents the *N-Gain* values and their corresponding categories for each research group. The results provide an additional descriptive indicator of changes in practical learning outcomes.

Table 4. N-Gain Results

Class	N-Gain	Category
Experimental	0.72	High
Control	0.38	Moderate

As shown in Table 4, the experimental class obtained an *N-Gain* value of 0.72, which was classified in the high category. The control class obtained an *N-Gain* value of 0.38, which was classified in the moderate category. The difference between the two *N-Gain* values was

https://doi.org/10.51878/learning.v6i4.13089

0.34. These results describe a higher level of improvement in the experimental class based on the *N-Gain* classification used in this study.

Normality Test Results

Before the hypothesis test was conducted, the distribution of the research data was examined using the *Kolmogorov-Smirnov* normality test. The normality test was performed to determine whether the data fulfilled the distributional assumption required for the planned parametric analysis. A significance value greater than 0.05 was used as the criterion for identifying normally distributed data. Table 5 presents the normality test results for the experimental and control classes.

Table 5. Results of the Normality Test

Group	Sig.	Description
Experimental Class	0.200	Normal
Control Class	0.173	Normal

Based on Table 5, the significance value for the experimental class was 0.200, while the control class obtained a significance value of 0.173. Both values were greater than the predetermined significance criterion of 0.05. Accordingly, the data for both groups met the normality criterion used in this study. The results presented in Table 5 were subsequently used as one of the statistical prerequisites for the next stage of analysis.

Homogeneity Test Results

The homogeneity test was conducted to examine the equality of variance between the two research groups. This test was performed using *Levene's test* before the comparison of group outcomes through parametric analysis. A significance value greater than 0.05 was used as the criterion for homogeneous variances. Table 6 presents the result of the homogeneity test for practical learning outcomes.

Table 6. Results of the Homogeneity Test

Variable	Sig.	Description
Practical Learning Outcomes	0.287	Homogeneous

As shown in Table 6, the significance value obtained from the homogeneity test was 0.287. This value exceeded the significance criterion of 0.05 established in the study. Based on the applied decision criterion, the variance of the practical learning outcome data was considered homogeneous. The result in Table 6 therefore fulfilled the homogeneity requirement for the subsequent parametric comparison.

Hypothesis Test Results

After the prerequisite tests indicated that the data met the specified assumptions, hypothesis testing was conducted using an *independent samples t-test*. The test was used to compare the practical learning outcomes of students in the experimental and control classes. The analysis was performed using a significance level of 0.05. Table 7 presents the calculated *t* value, significance value, and statistical decision obtained from the hypothesis test.

https://doi.org/10.51878/learning.v6i4.13089

Table 7. Independent Samples t-Test Results for Practical Learning Outcomes

Variable	Calculated t	Sig.	Decision
Practical Learning Outcomes	5.842	0.000	H_0 Rejected

Based on Table 7, the calculated *t* value was 5.842 with a significance value of 0.000. The obtained significance value was lower than the predetermined significance level of 0.05. Therefore, the null hypothesis concerning practical learning outcomes was rejected. The statistical result presented in Table 7 indicates a significant difference in practical learning outcomes between the experimental and control classes.

Discussion

The findings demonstrate that the implementation of *Problem-Based Learning* contributed to a more active learning process in ship machinery practice. Students in the experimental class showed higher levels of participation, collaboration, attention, and involvement in practical activities than those in the control class. This result suggests that the improvement was not merely associated with the completion of learning tasks, but with a shift in the students' role from recipients of technical instructions to active participants in identifying and responding to practical problems. The finding is consistent with Salam et al. (2026), who reported that PBL improved both student activity and learning outcomes in motorcycle chassis instruction at a vocational school. A similar pattern was identified by Rafiq et al. (2023), who found that the integration of inquiry and problem-based learning increased vocational students' involvement by creating opportunities for exploration and active participation. In this study, the increased engagement can therefore be interpreted as a consequence of learning situations that required students to discuss technical conditions, exchange ideas, and take responsibility for developing solutions rather than relying exclusively on teacher explanations.

The improvement in student engagement also indicates that the effectiveness of PBL is closely related to the structure of learning activities provided to students. Engagement in vocational learning should not be understood solely as physical participation, because meaningful involvement also includes students' cognitive attention, persistence, interaction, and willingness to contribute to the learning process. Although Fatahillah et al. (2025) examined student engagement through a different instructional approach, their findings reinforce the broader argument that the selection of learning strategies can influence the degree to which vocational students participate actively in classroom activities. The present findings extend this perspective by showing that PBL can create engagement through problem orientation and collaborative investigation, particularly when students are confronted with practical situations that require collective decision-making. Thus, the contribution of PBL in this context lies not only in making students more active, but also in creating conditions in which active participation becomes necessary for completing practical tasks. This interpretation is important because ship machinery practice requires students to remain involved throughout the processes of identifying problems, selecting procedures, implementing solutions, and evaluating outcomes.

The findings further reveal that students who experienced PBL demonstrated stronger problem-solving skills than students who received conventional instruction. This improvement suggests that repeated exposure to practical problems enabled students to move beyond the mechanical application of procedures toward a more analytical process of identifying problems and considering alternative solutions. The result is consistent with Mulianti et al. (2023), who found that a PBL approach supported the improvement of problem-solving ability among vocational high school students. Although the study by Mulianti et al. (2023) was conducted in a mathematical context and incorporated *augmented reality*, the similarity in findings suggests that the problem-oriented structure of learning may remain beneficial across different vocational and learning domains. The present study also has a particularly strong contextual connection with Taruna and Marwiyah (2026), who examined the strengthening of *problem-solving* skills through PBL in ship machinery maintenance systems. The convergence between these findings indicates that PBL is especially relevant for technical learning environments in which students are expected to diagnose operational problems and make appropriate decisions based on available information.

The improvement in problem-solving skills can also be interpreted through the principles of constructivist learning, in which understanding develops through active interaction with problems and learning experiences. Rather than receiving a predetermined solution at the beginning of instruction, students in the experimental class were encouraged to construct their understanding by examining the characteristics of practical problems and determining possible responses. This interpretation is supported by Suryati et al. (2023), who discussed vocational education within a constructivist perspective and emphasized the importance of learning processes that enable students to actively construct knowledge. The results also correspond with Ihsan and Syah (2026), who highlighted the potential of a *deep learning* approach in technical learning to promote a more meaningful understanding of learning content. In the present study, the relationship between *deep learning* and PBL can be understood as a process in which authentic problems encouraged students not only to know what procedure should be followed, but also to understand why a particular procedure or solution was appropriate. Consequently, the improvement in problem-solving ability reflects a deeper change in the way students engaged with technical knowledge rather than a simple increase in test performance.

The positive effect of PBL was also reflected in students' practical learning outcomes, as the experimental class achieved higher posttest scores and a higher *N-Gain* than the control class. This result indicates that problem-oriented learning can support the integration of conceptual understanding and practical performance. Jayahartwan and Sudirman (2022) similarly reported that the application of PBL contributed to improved learning outcomes, supporting the argument that students may achieve stronger learning performance when they are actively involved in analyzing and addressing problems. Lesmana (2025) also emphasized the potential influence of problem-based instructional strategies within vocational education, further supporting the relevance of this model for competency-oriented learning. In the context of the present study, improved practical outcomes may have resulted from the repeated connection between technical concepts and the actions required to address problems encountered during ship machinery practice. Therefore, the advantage of PBL appears to extend beyond cognitive achievement because the learning process provided students with opportunities to apply knowledge within practical and contextually meaningful situations.

Nevertheless, the results should also be interpreted by considering the characteristics of active learning models and the specific context of vocational education. Studies using other approaches have shown that active and project-oriented learning can also contribute to the development of higher-order competencies, including creativity, critical thinking, and problem-solving. For example, Wibowo (2026) reported that *Project-Based Learning* supported the development of creativity and mathematical problem-solving skills among vocational students, while Ogunbote et al. (2026) found that project-based instruction enhanced critical thinking and

https://doi.org/10.51878/learning.v6i4.13089

problem-solving among technical education students. These findings do not suggest that PBL is the only effective instructional approach; instead, they indicate that learning models requiring students to investigate, create, analyze, and make decisions share important characteristics that can support competency development. However, PBL has a distinctive relevance to ship machinery practice because the learning process can begin directly with a technical problem that resembles challenges encountered in practical and occupational settings. The present findings therefore contribute by demonstrating that a problem-oriented approach can simultaneously support engagement, analytical problem-solving, and practical learning performance within a maritime vocational context.

Overall, the findings provide a more integrated understanding of how PBL can function within ship machinery practice. Previous studies have generally demonstrated positive effects of PBL or other active learning approaches on particular outcomes, such as student activity, learning outcomes, critical thinking, or problem-solving skills (Jayahartwan & Sudirman, 2022; Mulianti et al., 2023; Ogunbote et al., 2026; Salam et al., 2026). The present study extends these findings by examining the simultaneous development of student engagement, problem-solving skills, and practical learning outcomes within one instructional setting, thereby providing a more comprehensive picture of the learning process. The results suggest that these three outcomes should not be viewed as entirely separate because increased engagement may create greater opportunities for students to explore problems, while stronger problem-solving processes may contribute to more effective practical performance. This relationship reinforces the value of integrating PBL with a *deep learning* orientation, particularly in vocational environments where students are expected to understand technical principles and apply them appropriately in authentic situations. From a practical perspective, the findings suggest that teachers in maritime vocational education can use authentic technical problems as the starting point for learning to develop students' active participation and technical reasoning while simultaneously supporting practical achievement.

CONCLUSIONS

The findings of this study indicate that the implementation of *Problem-Based Learning* (PBL) in ship machinery practical instruction provides a meaningful pedagogical alternative for shifting learning from procedural task completion toward active problem exploration. The use of authentic technical problems encourages students to participate more intensively in the learning process, develop systematic strategies for addressing practical difficulties, and construct a stronger connection between conceptual understanding and hands-on activities. In this context, the contribution of PBL extends beyond improving measurable learning performance, as it also supports the development of student engagement and problem-solving competence required in vocational practice. Therefore, the study confirms that a problem-oriented learning environment is compatible with the characteristics of ship machinery education, where students are expected not only to follow established procedures but also to respond appropriately to technical problems encountered during practical work.

The results also provide implications for the future development of vocational learning, particularly in maritime education. Teachers may adapt PBL to practical subjects by designing contextual cases that reflect technical challenges and workplace situations relevant to students' prospective professional environments. At the institutional level, the findings may serve as a reference for developing practical learning designs that integrate technical competence with active participation, analytical reasoning, and independent decision-making. Future studies

https://doi.org/10.51878/learning.v6i4.13089

should expand the implementation across different vocational schools, involve larger and more diverse participant groups, and examine the sustainability of learning effects over a longer period. Further investigation may also explore additional outcomes, such as creativity, communication, work readiness, and collaborative competence, to provide a broader understanding of how PBL can contribute to the preparation of adaptive and competent vocational graduates.

REFERENCES

Anthony, R., Wagino, W., Koto, R. D., Alwi, E., Purwanto, W., & Fernandez, D. (2025). Meta-analysis: The effect of problem-based learning in improving students' critical thinking in vocational education. *VANOS Journal of Mechanical Engineering Education*, *10*(1), 28–44. https://jurnal.untirta.ac.id/index.php/vanos/article/view/29826

Arjaya, I. B. A., Hermawan, I. M. S., Surata, S. P. K., Sari, N. K. S. P., Wati, K. U. P., & Dema, K. (2025). Optimalisasi pengembangan bahan ajar berbasis deep learning dan artificial intelligence dalam pendidikan vokasi. *Jurnal Pengabdian Masyarakat Bangsa*, *3*(4), 1730–1740. https://jurnalpengabdianmasyarakatbangsa.com/index.php/jpmba/article/view/2557

Englita, L., Mukhlis, M., Hairiyah, S., Wahyuni, L., Sutrisna, N., & Ikhlas, A. (2026). Implementasi model pembelajaran berbasis proyek (Project-Based Learning) untuk meningkatkan literasi numerasi mahasiswa. *Indo Green Journal*, *4*(3), 552–559. https://idngreen.com/index.php/green/article/view/688

Fadhilah, N., Fiardi, A., & Nurman, S. (2026). Pengembangan bahan ajar termodinamika berbasis STCW untuk meningkatkan kompetensi taruna permesinan kapal. *Jurnal Maritim Malahayati*, *7*(1), 410–415. https://journal.poltekpelaceh.ac.id/index.php/jumama/article/view/155

Fatahillah, M. A., Ichwanto, M. A., & Sudarto, S. (2025). Eksplorasi pengaruh metode giving terhadap keterlibatan siswa dalam pembelajaran di sekolah menengah kejuruan. *NUSRA: Jurnal Penelitian dan Ilmu Pendidikan*, *6*(1), 20–28. https://doi.org/10.55681/nusra.v6i1.3282

Ihsan, M., & Syah, N. (2026). Penerapan pendekatan *deep learning* pada pembelajaran teknik. *Jurnal Sains, Informasi dan Teknologi*, *1*(3), 54–62. https://jurnal.insanciptamedan.or.id/index.php/sitek/article/view/852

Jaya, A., Hartono, R., Syafri, F., & Haryanti, R. P. (2023). Analisis tuntutan Kurikulum Merdeka dalam konteks penerapan keterampilan abad 21 pada materi pembelajaran bahasa Inggris. *Prosiding Seminar Nasional Pascasarjana Universitas Negeri Semarang*, *6*(1), 142–147. https://proceedings.unnes.ac.id/snpasca/article/view/2110

Jayahartwan, M., & Sudirman, S. (2022). Penerapan model pembelajaran Problem Based Learning untuk meningkatkan hasil belajar. *Jurnal Pendidikan dan Profesi Keguruan*, *1*(2), 102–110. https://doi.org/10.59562/progresif.v1i2.29334

Laili, A. Q., Arianto, F., & Khotimah, K. (2025). Systematic literature review: Problem-Based Learning dalam praktikum kelistrikan terhadap kemampuan berpikir kritis siswa SMK. *JIIP: Jurnal Ilmiah Ilmu Pendidikan*, *8*(8), 9361–9366. https://doi.org/10.54371/jiip.v8i8.8993

Lesmana, A. S. (2025). Analisis pengaruh strategi pembelajaran berbasis masalah terhadap pendidikan vokasional. *HUMANITIS: Jurnal Humaniora, Sosial dan Bisnis*, *3*(4), 649–656. https://ecosemica.net/index.php/HUMANITIS/article/view/825

Mulianti, S., Susanta, A., Hanifah, H., & Haji, S. (2023). Pengaruh pendekatan Problem-Based Learning (PBL) berbantuan augmented reality (AR) terhadap kemampuan pemecahan masalah matematika di SMK Negeri 1 Lebong. *Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika, 4*(2), 930–939. https://doi.org/10.46306/lb.v4i2.358

Ogunbote, S., Dawodu, R. A., & Omotayo, F. A. (2026). Effectiveness of Project-Based Learning in enhancing critical thinking and problem-solving skills among technical education students in Lagos State technical colleges. *Journal of Contemporary Academic Research and Methodologies (JCARM), 1*(4), 338–354. https://journal.jcarm.in/index.php/home/article/view/190

Pratama, W. (2026). Integrating character education into maritime vocational learning: Evidence from Indonesian vocational schools. *VANOS Journal of Mechanical Engineering Education, 11*(1), 140–152. https://jurnal.untirta.ac.id/index.php/vanos/article/view/39530

Rafiq, A. A., Triyono, M. B., & Djatmiko, I. W. (2023). The integration of inquiry and problem-based learning and its impact on increasing the vocational student involvement. *International Journal of Instruction, 16*(1), 659–684. https://doi.org/10.29333/iji.2023.16137a

Salam, I. D., Martias, Maksum, H., & Fernandez, D. (2026). Efektivitas model Problem Based Learning dalam meningkatkan keaktifan dan hasil belajar siswa pada pembelajaran sasis sepeda motor di SMK Negeri 1 Luak. *JTPVI: Jurnal Teknologi dan Pendidikan Vokasi Indonesia, 4*(2), 1–10. https://jtpvi.ppj.unp.ac.id/index.php/jtpvi/article/view/345

Saputra, B. G., Partono, & Djunaedi, I. (2025). Implementasi model pembelajaran Problem Based Learning untuk meningkatkan minat belajar kompetensi whell alignment siswa kelas XI TKR di SMK Nasional Malang. *Jurnal Pendidikan Vokasi Otomotif, 7*(2), 42–54. https://doi.org/10.21831/jpvo.v7i2.84827

Sari, R. K. S. (2023). Upaya meningkatkan kemampuan pemecahan masalah matematis siswa SMK dengan pembelajaran berbasis masalah berbantuan Geogebra. *Eksponen, 13*(1), 25–36. https://doi.org/10.47637/eksponen.v13i1.682

Siregar, J., Badriah, A., Aprilia, S., & Saifudin, A. (2025). Integrasi manajemen pendidikan, *deep learning*, dan AI dalam pembelajaran berbasis masalah di SMK kesehatan: Integration of educational management, deep learning, and AI in problem-based learning at health vocational schools. *Al-Gafari: Manajemen dan Pendidikan, 3*(2), 122–140. https://doi.org/10.66886/algafari-mp.v3i2.202

Suryati, L., Jalinus, N., Abdullah, R., & Rahmadhani, S. (2023). Dampak penerapan Kurikulum Merdeka dalam prespektif filsafat konstruktivisme pada pendidikan vokasi. *Jurnal Penelitian dan Pengembangan Pendidikan, 7*(2), 195–202. https://doi.org/10.23887/jppp.v7i2.57408

Taruna, T., & Marwiyah, M. (2026). Penguatan keterampilan problem solving melalui model PBL pada sistem perawatan permesinan kapal. *NUSRA: Jurnal Penelitian dan Ilmu Pendidikan, 7*(2), 292–305. https://doi.org/10.55681/nusra.v7i2.6092

Wibowo, C. T. (2026). Menumbuhkan kreativitas dan kemampuan memecahkan masalah matematika siswa SMK melalui model Project-Based Learning. *Jurnal Pendidikan dan Teknologi Pembelajaran Matematika, 3*(1), 124–134. https://jurnal.ut.ac.id/index.php/edumathtec/article/view/15086

Zariayufa, K., Cahyadi, S., & Witriani, W. (2022). Peran dukungan orang tua, guru & teman sebaya terhadap keterlibatan siswa SMK dalam pembelajaran daring. *Jurnal Educatio FKIP UNMA*, *8*(3), 973–980. https://doi.org/10.31949/educatio.v8i3.3018

https://doi.org/10.51878/learning.v6i4.13089