



Effect of Problem-Based Learning on Vocational Students' Creative Products and Entrepreneurship (PKK) Outcomes in an Indonesian Public Vocational School

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ABSTRACT

Entrepreneurship-oriented learning in vocational schools requires instructional approaches that promote active inquiry, practical competence, and meaningful engagement. This study examined the effect of problem-based learning on Grade XI students' learning outcomes in Creative Products and Entrepreneurship at SMK Negeri 4 Gorontalo. A quantitative, causal design was used with total sampling of 32 students. Data were collected using structured questionnaires and supporting documentation, and were analysed using simple linear regression with assumption checking through a residual normality test. Results show that students perceived problem-based learning implementation as very strong across its core stages, and learning outcomes were similarly rated very highly across cognitive, affective, and psychomotor domains. The regression model indicates a positive association between problem-based learning and learning outcomes, supported by a statistically significant coefficient. The relationship is strong, and the model explains more than half of the variance in learning outcomes, suggesting that problem-based learning is a substantial instructional contributor to entrepreneurship-related attainment in this context. Nonetheless, a meaningful proportion of outcome variance remains linked to other influences. These findings indicate that consistent implementation of problem-based learning can improve vocational students' entrepreneurial learning outcomes and that optimisation efforts should be complemented by supportive conditions such as adequate learning facilities and motivational supports.

Keywords : *Problem-based learning; entrepreneurship education; learning outcomes*

Introduction

Education is widely recognized as a central lever for strengthening human resources and expanding national competitiveness. In the Indonesian context, this strategic role is explicitly articulated in Law No. 20 of 2003, which frames education as a deliberate and planned process to create learning conditions that enable students to actively develop spiritual, personal, intellectual, moral, and practical competencies needed by individuals and society (Law No. 20, 2003). Such a mandate implies that schooling should not only transmit content knowledge but also cultivate dispositions and capacities for lifelong learning, ethical decision-making, and productive participation in social and economic life. In recent decades, global educational discourse has similarly emphasized the need to align classroom practices with twenty-first-century competencies, including problem solving, critical and creative thinking, and collaboration. Consequently, the effectiveness of teaching approaches is increasingly judged by their ability to promote meaningful engagement and measurable improvement in learner outcomes rather than by the coverage of curricular material alone.

From a broader perspective, education functions as a mechanism for shaping competitive individuals in diverse sectors, encompassing not merely classroom instruction but also wider social activities that strengthen human resources and support holistic development across cognitive, affective, and psychomotor domains (Hermino, 2014). This view aligns with contemporary learning theories that position students as active constructors of knowledge whose understanding develops through interaction, reflection, and contextualized practice. Within this paradigm, effective instruction is expected to be interactive, inspiring, challenging, and learner-centered, with teachers designing learning experiences that intentionally involve students in inquiry and application. However, the persistent gap between these ideals and everyday practice remains a recurring concern. Empirical accounts indicate that many teachers still rely on undifferentiated, lecture-dominant methods that limit opportunities for student participation, thereby constraining higher-order thinking and diminishing motivation (Wiguma Minat et al., 2022). These conditions are particularly consequential in vocational education, where the curriculum is inherently oriented toward competence development and where instructional quality directly influences students' readiness for further training, entrepreneurship, or employment.

A pressing issue in vocational schooling is that learning outcomes can remain suboptimal when instructional practices are not aligned with the applied nature of vocational competencies. In entrepreneurship-related subjects, teacher-centered approaches may reduce students to passive recipients of information, leaving limited room for exploration, initiative, and authentic decision-making. Such patterns can weaken the development of creative and analytical thinking that entrepreneurship education explicitly demands. In the context of Indonesian

vocational high schools, the subject Creative Products and Entrepreneurship (Produk Kreatif dan Kewirausahaan/PKK) aims to build students' creativity, product innovation, and entrepreneurial competence through iterative processes such as identifying opportunities, designing products, planning business models, and analyzing markets. When the learning process emphasizes memorization over exploration, students may struggle to connect concepts to real entrepreneurial challenges and to internalize entrepreneurial mindsets. Diagnostic observations in PKK classrooms at SMKN 4 Gorontalo, for instance, have indicated low student participation and limited variation in learning models, with achievement levels frequently below the expected minimum mastery criterion.

The central research problem emerging from this situation is how to design instruction that both aligns with the competency-based character of vocational entrepreneurship learning and demonstrably improves student outcomes. A general response to low learning outcomes has been to advocate for student-centered pedagogies that activate learners' prior knowledge, promote collaborative inquiry, and provide opportunities to apply knowledge to practical situations. These solutions are grounded in the principle that learning is strengthened when students engage with meaningful tasks, reflect on their reasoning, and receive feedback through iterative practice. Nonetheless, translating such principles into consistent classroom practice requires a structured instructional model that is feasible for teachers, coherent with curricular standards, and capable of addressing diverse learning needs. The continuing reliance on monotonous, lecture-based instruction often associated with limited differentiation and minimal model variation has been identified as a critical contributor to student passivity, boredom, and reduced engagement (Wiguma Minat et al., 2022). Therefore, identifying an instructional approach that offers clear stages, encourages active participation, and targets both knowledge and skill outcomes constitutes a practical and theoretical priority.

Problem-Based Learning (PBL) has been widely proposed as a systematic model for addressing these challenges, particularly in domains requiring applied reasoning and performance. PBL emphasizes contextual problem-solving by presenting students with real or realistic problems at the outset of learning, then guiding them to identify what they need to know, analyze information, and develop solutions individually and collaboratively (Widuri & Madiun, 2022). In doing so, PBL shifts the locus of classroom activity from teacher explanation to student investigation, while still providing a structured sequence of learning stages. This structure is especially relevant to PKK because entrepreneurial competence is inherently problem-oriented: students must define needs, evaluate constraints, generate ideas, test alternatives, and justify decisions. By embedding learning in authentic entrepreneurial scenarios such as product design decisions, customer value propositions, and market feasibility PBL can provide the type of situated learning environment that vocational entrepreneurship education requires. Theoretically, such environments enable students to connect concepts to practice and to build transferable problem-solving strategies.

Evidence from prior empirical studies supports the effectiveness of PBL for improving learning outcomes and higher-order thinking. Experimental quantitative research has shown that PBL can significantly increase students' achievement compared with conventional methods, with active, collaborative, and problem-focused learning enhancing conceptual understanding and classroom engagement (Nusi et al., 2024). In related work, PBL has been reported to strengthen secondary students' critical thinking skills and conceptual mastery, enabling learners to connect theoretical ideas to real-world contexts more effectively than peers taught through traditional, teacher-centered instruction (Fitriani et al., 2024). Moreover, improvements are not limited to cognitive attainment; students frequently report greater involvement and responsibility within PBL environments, which contributes to stronger autonomy and accountability in learning (Nofziarni et al., 2024). Collectively, these studies suggest that PBL is not merely an alternative teaching strategy but a comprehensive learning model capable of supporting multi-dimensional outcomes aligned with vocational education's cognitive, affective, and psychomotor goals.

Despite the growing body of evidence, the literature also indicates that the effectiveness of PBL is contingent on contextual factors, including classroom culture, teacher facilitation skills, learning resources, and institutional support. While the cited studies demonstrate benefits across different settings, many investigations focus on general academic subjects or non-vocational contexts, leaving an incomplete understanding of PBL's influence within vocational entrepreneurship learning that involves product creation and business-oriented performance tasks. Additionally, although PBL is conceptually well-suited to PKK, localized empirical validation remains essential because vocational schools differ in student characteristics, facilities, and community economic environments. In classrooms where achievement is markedly low—as reflected in preliminary PKK assessment data in which a substantial proportion of Grade XI students do not meet the minimum mastery criterion—there is a need to examine whether PBL can function as an effective intervention and to what extent it explains variability in student outcomes. This need becomes more pressing when conventional instruction persists despite curriculum expectations for active learning.

Accordingly, the present study investigates the effect of implementing the Problem-Based Learning model on Grade XI students' PKK learning outcomes at SMKN 4 Gorontalo. Building on the educational mandate for holistic competency development (Law No. 20, 2003) and on conceptual and empirical accounts of learner-centered, problem-oriented instruction (Hermino, 2014; Widuri & Madiun, 2022; Nusi et al., 2024; Fitriani et al., 2024; Nofziarni et al., 2024), this research advances the proposition that PBL positively influences vocational students' achievement in entrepreneurship-oriented learning. The novelty of the study lies in its focused examination of PKK in a public vocational school context where teacher-centered practices and low mastery levels have been documented, thereby providing a context-sensitive test of PBL's explanatory power for outcomes spanning

knowledge, attitudes, and skills. The scope of the study is limited to Grade XI PKK learning at SMKN 4 Gorontalo, with analysis centered on the relationship between the degree of PBL implementation and students' learning outcomes, while acknowledging that additional factors beyond instructional model may also contribute to performance differences.

Methodology.

The study employed a quantitative approach grounded in positivist philosophy. Quantitative research is appropriate when the researcher intends to test pre-formulated hypotheses using measurable indicators, structured instruments, and statistical analysis on a defined population or sample (Sugiyono, 2019). In this research, the independent variable was the implementation of the Problem-Based Learning model (PBL) in PKK classes, and the dependent variable was Grade XI students' PKK learning outcomes. The approach was operationalized through standardized questionnaires that produced numerical scores for both variables, enabling inferential testing of the proposed influence of PBL on learning outcomes. Consistent with the national orientation that learning should develop students' competencies through deliberate and planned educational processes, the quantitative approach was used to determine whether a structured instructional model could be associated with measurable differences in students' achievement (Law No. 20, 2003).

Results.

Overview of Research Data

This section reports the empirical results of the quantitative analysis examining the influence of Problem-Based Learning (PBL) on Grade XI students' learning outcomes in the Creative Products and Entrepreneurship (Produk Kreatif dan Kewirausahaan/PKK) subject at SMK Negeri 4 Gorontalo. The dataset comprised responses from 32 students, reflecting the full Grade XI cohort in the 2025 school year. Data for the independent variable (PBL implementation) and the dependent variable (learning outcomes) were collected using structured Likert-scale questionnaires and processed using IBM SPSS Statistics version 21.0. This analytical procedure follows the quantitative principle that statistical analysis is conducted after all respondent data have been collected through standardized instruments to test pre-formulated hypotheses (Sugiyono, 2019). The reporting emphasizes both descriptive characteristics of each variable and the inferential outputs of regression modelling, including assumptions testing, parameter estimates, statistical significance, and explanatory power. The interpretation is

framed within the broader pedagogical expectation that effective instruction should promote active learning and competence development as mandated in Indonesian education policy (Law No. 20, 2003) and within evidence that PBL supports deeper engagement and improved achievement through contextual problem solving and collaborative inquiry (Widuri & Madiun, 2022; Nusi et al., 2024).

Descriptive Statistics of Problem-Based Learning

Descriptive statistics for the PBL variable indicate that students perceived the implementation of PBL in PKK learning as generally strong and relatively consistent across the cohort. The analysis yielded $N = 32$, with a mean score of 99.78, a median of 100.00, and a mode of 92.00. The dispersion measures show a standard deviation of 7.59 and a variance of 57.60, suggesting moderate variability around the mean. Observed values ranged from 91.00 to 115.00, producing a range of 24.00 and a total score sum of 3,193.00. The concentration of scores within this interval implies that students' appraisals of the learning model were clustered within a relatively narrow band, which is consistent with the expectation that the intervention was implemented systematically at the classroom level rather than sporadically. Such coherence is educationally important because PBL depends on a staged learning process that begins with contextual problems and progresses through organized inquiry, investigation, product presentation, and reflective evaluation (Widuri & Madiun, 2022).

Descriptive Statistics of Problem-Based Learning (X). Presents the measures of central tendency and dispersion for the PBL variable, including mean, median, mode, standard deviation, variance, range, minimum, maximum, and total score.

To better understand score patterns, a frequency distribution was constructed for the PBL variable. The distribution comprises five intervals: 91–96 (14 students; 43.8%), 97–101 (3 students; 9.4%), 102–106 (7 students; 21.9%), 107–110 (5 students; 15.6%), and 111–115 (3 students; 9.4%). This pattern indicates that the largest proportion of students was concentrated in the 91–96 interval, suggesting a moderate–lower clustering within the observed scale. At the same time, a substantial share of students fell in higher intervals, with 21.9% in 102–106 and 15.6% in 107–110, while 9.4% reached the highest interval of 111–115. This distribution suggests that although student perceptions of PBL were predominantly favorable, there was still meaningful variation in how intensively students experienced the model's stages, which may reflect differences in group dynamics, participation opportunities, or individual engagement during problem-solving processes.

Frequency Distribution of Problem-Based Learning (X). Reports the number and percentage of students across five PBL score intervals, providing a distributional profile of students' perceptions of PBL implementation.

Beyond overall scores, the PBL construct was examined through indicator-based descriptions aligned with established conceptualizations of effective PBL.

Drawing on the five-stage structure of PBL, which includes orienting students to contextual problems, organizing students for learning, guiding investigations, developing and presenting work, and analyzing and evaluating the problem-solving process (Tekisendi in Nusi et al., 2024), the study calculated mean Likert scores (1–5) for each indicator. The indicator means were high across the board: orienting students to problems (mean = 4.37), organizing students for learning (4.36), guiding investigation (4.30), developing and presenting work (4.30), and analyzing and evaluating solutions (4.34). The overall mean for the PBL variable was 4.34, categorized as “Very Good.” The highest mean was observed in orienting students to problems, which indicates that students strongly recognized the presence of contextual problem situations as an entry point to learning. The slightly lower—though still “Very Good”—means for guiding investigation and for developing and presenting work may suggest that these stages, which require sustained facilitation and student initiative, can be more challenging to optimize consistently in vocational classrooms. Nevertheless, the pattern supports prior reports that structured PBL stages create learning environments that are active, collaborative, and motivating, enhancing students’ conceptual understanding and engagement (Nusi et al., 2024; Fitriani et al., 2024).

Descriptive Statistics of Learning Outcomes

Descriptive statistics for students’ PKK learning outcomes show that overall performance was concentrated at mid–high levels across the sample. The analysis yielded $N = 32$ with a mean of 86.53, median of 86.00, and mode of 91.00. Dispersion metrics show a standard deviation of 4.77 and variance of 22.77, indicating that outcome scores were relatively tightly grouped around the mean. The observed minimum score was 79.00 and the maximum was 95.00, producing a range of 16.00 and a total score sum of 2,769.00. The narrow range and moderate standard deviation indicate generally stable performance across the cohort, suggesting that the PKK learning process produced broadly consistent attainment despite differences in students’ vocational majors. Interpreting learning outcomes as multidimensional attainment is consistent with the conception that outcomes include cognitive, affective, and psychomotor domains that reflect knowledge acquisition, attitudinal development, and practical performance after instruction (Sudjana in Widyanto, 2017).

Descriptive Statistics of Students’ Learning Outcomes (Y). Presents measures of central tendency and dispersion for learning outcome scores, including mean, median, mode, standard deviation, variance, range, minimum, maximum, and total score.

The learning outcomes frequency distribution was divided into five intervals: 79–82 (8 students; 25.0%), 83–85 (4 students; 12.5%), 86–88 (8 students; 25.0%), 89–91 (8 students; 25.0%), and 92–95 (4 students; 12.5%). This pattern indicates that three intervals each contained eight students, producing a balanced clustering

in 79–82, 86–88, and 89–91. The distribution suggests that many students performed strongly, with substantial proportions located in the 86–95 range. At the same time, one-quarter of the cohort remained in the lowest interval (79–82), which signals that achievement disparities persisted and that not all students experienced equivalent benefits or engagement. This outcome is pedagogically plausible because, even when instructional quality improves, learning performance can still be shaped by other individual and contextual factors, including motivation, learning facilities, and external educational support (Meliyana et al., 2023; Gobel et al., 2023; Halid et al., 2025).

Frequency Distribution of Learning Outcomes (Y). Reports the number and percentage of students across five learning outcome score intervals, providing a distributional profile of PKK achievement.

Indicator-based analysis further examined learning outcomes across the three domains commonly used in Indonesian assessment discourse. The cognitive domain obtained a mean of 4.32, the affective domain 4.35, and the psychomotor domain 4.30, yielding an overall mean outcome score of 4.32 categorized as “Very Good.” Within the cognitive domain, item means ranged from 4.25 to 4.44, indicating consistently high perceptions of conceptual mastery. Affective items ranged from 4.25 to 4.53, including the highest single value (4.53), which suggests that students perceived strong gains in attitudes such as responsibility, interest, and engagement dimensions that prior research associates with PBL’s emphasis on learner involvement and autonomy (Nofziarni et al., 2024). Psychomotor items ranged from 4.25 to 4.34, showing stable ratings for performance-based skills, which is particularly relevant for vocational entrepreneurship learning where product development and practical tasks are central. This three-domain pattern aligns with the view that learning outcomes encompass cognitive understanding, affective dispositions, and psychomotor performance demonstrated after instruction (Sudjana in Widyanto, 2017), and it supports earlier findings that PBL strengthens critical thinking and real-world application by requiring students to connect theory to practical problem contexts (Fitriani et al., 2024).

Instrument Validity Results

Before inferential testing, the measurement instruments were evaluated for validity to ensure that questionnaire items accurately represented the constructs of interest. Item validity was assessed using the Pearson Product Moment correlation between each item score and the total score of the corresponding variable, following the criterion that an item is valid when the calculated correlation coefficient exceeds the critical value in the *r*-table at $\alpha = 0.05$ (Sugiyono, 2019). For the PBL variable, Table 4.7 reports 23 items with *r*-count values ranging from 0.510 to 0.769. All values exceeded *r*-table = 0.349, leading to the conclusion that all PBL items were valid and retained for subsequent analysis. These results indicate that the

instrument adequately captured students' experiences of core PBL processes, which are central to interpreting the model's influence on learning outcomes.

Validity of Problem-Based Learning Variable (X). Reports Pearson item-total correlation coefficients for 23 PBL items, demonstrating that each item's r -count exceeds the r -table criterion at $\alpha = 0.05$.

For the learning outcomes variable, validity testing similarly showed acceptable item functioning. Table 4.8 reports 20 items with r -count values ranging from 0.365 to 0.609, all exceeding the same r -table value of 0.349. Therefore, all learning outcome items were declared valid indicators of the intended domains. This finding is important because the outcome construct was operationalized to represent multi-domain achievement. Ensuring that items are valid supports the credibility of claims linking PBL implementation to measured learning outcomes, especially when outcomes are interpreted as including cognitive, affective, and psychomotor domains (Sudjana in Widyanto, 2017).

Validity of Learning Outcomes Variable (Y). Reports Pearson item-total correlation coefficients for 20 learning outcome items, showing that all items meet the validity criterion at $\alpha = 0.05$.

Instrument Reliability Results

Instrument reliability testing was conducted to examine internal consistency, consistent with the principle that reliable instruments yield stable and consistent results when applied under comparable conditions (Sugiyono, 2017). The reliability results in Table 4.9 show Cronbach's Alpha values of 0.941 for the PBL instrument and 0.836 for the learning outcomes instrument. Both values exceeded the comparison threshold of r -table = 0.600, leading to the conclusion that both instruments were reliable. The high alpha value for the PBL scale suggests excellent internal consistency, indicating that the set of items coherently represented the PBL construct. The learning outcomes scale also demonstrated strong reliability, supporting the use of the composite outcome score in regression modelling. Taken together, the validity and reliability evidence provides a robust measurement foundation for interpreting subsequent regression and hypothesis-testing results.

Instrument Reliability Test. This table presents Cronbach's Alpha values for the PBL (X) and learning outcomes (Y) instruments, demonstrating that both scales meet the reliability criteria.

Normality Test of Regression Residuals

The normality of regression residuals was tested as an assumption check before conducting hypothesis testing within the linear regression framework. A good regression model requires residuals that are normally distributed; within the Kolmogorov-Smirnov (K-S) test, residuals are considered normal when the significance value exceeds 0.05 (Ghozali, 2018). Table 4.10 reports a K-S test for

unstandardized residuals with $N = 32$, mean = 0.0000000, standard deviation = 3.25, K-S $Z = 0.597$, and Asymp. Sig. (2-tailed) = 0.869. Because the Asymp. Sig. value is greater than 0.05, the residuals were concluded to be normally distributed. This result indicates that the normality assumption for simple linear regression was satisfied, supporting the appropriateness of using regression coefficients and their associated significance tests to draw inferences about the relationship between PBL and learning outcomes.

Normality Test. This table presents Kolmogorov–Smirnov statistics for unstandardized residuals, including test values and the Asymptotic significance used to evaluate residual normality.

Simple Linear Regression Analysis

Simple linear regression analysis was used to estimate the effect of PBL implementation (X) on learning outcomes (Y). The estimated regression equation was $\hat{Y} = 40.609 + 0.460X$. The constant value of 40.609 represents the predicted learning outcome score when the PBL predictor value is zero within the model specification. Although a zero PBL score is not practically observed in the empirical scale, the intercept serves as the baseline parameter in the regression function. The slope coefficient $b = 0.460$ indicates that each one-unit increase in the PBL score is associated with an expected increase of 0.460 points in students' learning outcomes. The positive direction of the coefficient indicates that stronger implementation of PBL stages corresponds to higher learning outcomes, which is consistent with theoretical arguments that PBL strengthens conceptual understanding and engagement by beginning with authentic problems and guiding learners through analysis and solution development (Widuri & Madiun, 2022). It is also consistent with empirical findings that PBL increases learning outcomes compared with conventional teaching because it activates collaborative inquiry and deeper participation (Nusi et al., 2024).

Hypothesis Testing Using t-Test

Hypothesis testing was conducted using the t-test to evaluate the partial significance of the regression coefficient for PBL. The t-test examines whether an independent variable significantly influences a dependent variable in a regression model; if the significance probability is less than 0.05, the effect is considered statistically significant (Ghozali, 2018). The coefficients output indicated that the PBL variable produced a t-count value of 5.883 with a significance value of $p = 0.000$, while the critical t-table value at $\alpha = 0.05$ was 2.036. Because t-count exceeded t-table and p was less than 0.05, the null hypothesis $H_0: \beta_1 = 0$ was

rejected and the alternative hypothesis $H_1: \beta_1 \neq 0$ was accepted. This result provides statistical evidence that PBL implementation significantly influences students' PKK learning outcomes. Substantively, the finding supports prior empirical work indicating that PBL enhances achievement by improving students' conceptual understanding and motivating deeper engagement through problem-focused learning (Nusi et al., 2024; Fitriani et al., 2024) and aligns with the pedagogical expectation that learning should be interactive and student-centered to generate sustained competence improvement (Law No. 20, 2003; Hermino, 2014).

Correlation and Coefficient of Determination

The strength of association between PBL and learning outcomes was evaluated through the correlation coefficient and the coefficient of determination. The model summary reported a Pearson correlation coefficient $R = 0.732$, indicating a strong positive relationship between PBL implementation and learning outcomes. Using the classification interval of 0.60–0.799, this value falls within the “Strong” association category. This strong correlation supports the descriptive observation that students who reported higher quality PBL experiences tended to report and demonstrate higher learning outcomes. Such a relationship is plausible given PBL's pedagogical design, which encourages learners to actively apply knowledge, collaborate, and reflect—processes associated with critical thinking and improved performance (Widuri & Madiun, 2022; Fitriani et al., 2024).

The coefficient of determination R^2 was 0.536, with an Adjusted R^2 of 0.520 and a standard error of estimate of 3.30551. R^2 indicates the proportion of variance in learning outcomes that is explained by the predictor within the regression model; higher values reflect stronger explanatory power (Ghozali, 2018). Thus, the result implies that 53.6% of the variance in Grade XI students' PKK learning outcomes was explained by PBL implementation scores. The remaining 46.4% of variance is attributable to other factors not included in the model. This residual proportion is theoretically meaningful because learning outcomes are shaped by multiple influences, including learner motivation and external conditions. Studies have shown, for example, that learning facilities can significantly affect outcomes by supporting concentration and active participation (Meliyana et al., 2023), while scholarship programmes can influence motivation and achievement by reducing economic constraints and enabling students to focus on study (Gobel et al., 2023; Halid et al., 2025). Consequently, the present results position PBL as a strong instructional contributor to PKK learning success while acknowledging that broader contextual supports also matter.

Coefficient of Determination of X on Y. Summarizes the correlation coefficient (R), the coefficient of determination (R Square), and the complementary contribution of other factors ($1 - R^2$), emphasizing the proportion of learning outcome variance explained by PBL and the remaining unexplained variance.

Summary of Result Interpretation

Overall, the results provide convergent evidence that PBL was implemented at a high quality level and that students' learning outcomes were similarly high across cognitive, affective, and psychomotor domains. The descriptive results show that the PBL variable achieved an overall mean of 4.34 ("Very Good") across its five indicators, consistent with the theoretical framing that effective PBL involves problem orientation, organized inquiry, guided investigation, product development and presentation, and reflective evaluation (Tekisendi in Nusi et al., 2024). Learning outcomes achieved an overall mean of 4.32 ("Very Good") across cognitive, affective, and psychomotor domains, consistent with the multi-domain conception of learning outcomes (Sudjana in Widyanto, 2017). The inferential analysis indicated that regression assumptions were satisfied through residual normality (Asymp. Sig. = 0.869 > 0.05), and the regression equation $\hat{Y} = 40.609 + 0.460X$ indicated a positive relationship between PBL and learning outcomes. Hypothesis testing confirmed that the relationship was statistically significant ($t = 5.883$, $p < 0.001$), leading to rejection of the null hypothesis. Correlation and determination results further indicated a strong association ($R = 0.732$) and substantial explanatory power ($R^2 = 0.536$), meaning that more than half of the variance in students' PKK learning outcomes was accounted for by differences in PBL implementation.

These findings reinforce prior literature suggesting that PBL improves achievement by fostering active, collaborative engagement and contextual application of concepts (Widuri & Madiun, 2022; Nusi et al., 2024; Fitriani et al., 2024; Nofziarni et al., 2024). At the same time, the residual unexplained variance highlights that instructional improvement alone may not fully determine student performance, and that complementary supports—such as adequate learning facilities and external assistance that strengthens motivation—may further enhance vocational learning results (Meliyana et al., 2023; Gobel et al., 2023; Halid et al., 2025). In the specific context of SMK Negeri 4 Gorontalo, the strong statistical relationship between PBL and learning outcomes suggests that systematic implementation of PBL is a promising pedagogical strategy for PKK learning, particularly for developing the knowledge, attitudes, and practical entrepreneurial skills expected of vocational students.

Discussion.

This study provides empirical evidence that the Problem-Based Learning (PBL) model exerts a positive and statistically significant influence on Grade XI students' learning outcomes in Creative Products and Entrepreneurship (PKK) at SMK Negeri 4 Gorontalo. The estimated regression equation, $\hat{Y} = 40.609 + 0.460X$, indicates that improvement in perceived PBL implementation is associated with higher predicted learning-outcome scores, and the t-test result ($t = 5.883$, $p < 0.001$) confirms that this relationship is unlikely to be due to sampling error. The observed

association is also practically meaningful: the correlation coefficient ($R = 0.732$) reflects a strong positive relationship between PBL and PKK outcomes, and the coefficient of determination ($R^2 = 0.536$) shows that more than half of the variance in learning outcomes can be explained by variation in PBL implementation. Together, these results support the central proposition that systematically structured, student-centred instruction grounded in authentic problems can improve the knowledge, attitudes, and vocational skills expected in entrepreneurship-oriented learning.

The descriptive results indicate that PBL was implemented with a high level of perceived quality in PKK classes, as reflected by the overall mean score of 4.34 (categorised as “Very Good”). Interpreting these results requires attention to what “implementation” signifies within PBL’s theoretical structure. In this research, PBL was operationalised through five indicators that mirror the essential learning cycle: orienting students to contextual problems, organising students for learning, guiding individual and group investigations, developing and presenting work, and analysing and evaluating the problem-solving process (Tekisendi in Nusi et al., 2024). High mean scores across all indicators imply that the core stages of the PBL cycle were present and recognizable to students, which is crucial because PBL is not a single technique but an integrated learning design in which each stage supports the next.

The highest indicator mean in this study was “orienting students to problems” (4.37), suggesting that the learning process successfully began with contextual entrepreneurial issues rather than abstract content delivery. This finding aligns with the argument that PBL emphasises contextual problem-solving by confronting learners with real-life problems early, prompting them to identify what they need to know and to build solutions through inquiry (Widuri & Madiun, 2022). In a PKK context, problem orientation has particular pedagogical value because entrepreneurship learning is inherently opportunity- and constraint-driven; students learn effectively when they must respond to realistic design, production, or market challenges. The slightly lower means for “guiding investigation” and “developing and presenting work” (both 4.30), although still “Very Good,” may reflect the increased instructional complexity of these stages. Investigation and product presentation require sustained facilitation, access to resources, and equitable group participation; therefore, they can be more sensitive to classroom management and facility conditions. Nonetheless, the high overall indicator profile suggests that teachers were able to enact the PBL sequence in a way that students experienced as coherent and supportive.

Learning outcomes were conceptualised as multidimensional attainment across cognitive, affective, and psychomotor domains, consistent with the view that student learning results include thinking and understanding (cognitive), attitudes and values (affective), and practical performance (psychomotor) demonstrated after instruction (Sudjana in Widyanto, 2017). The overall mean outcome score of 4.32 (“Very Good”) indicates that students perceived strong development across these domains under the PBL learning environment. Notably, the affective domain

achieved the highest mean (4.35), followed closely by cognitive (4.32) and psychomotor (4.30). This pattern is theoretically plausible because PBL can strengthen affective outcomes by increasing students' sense of involvement, ownership, and responsibility for learning, which supports learning autonomy and accountability (Nofziarni et al., 2024).

The distribution of numerical achievement scores (79–95, mean 86.53) suggests generally good mastery, while still revealing variation within the cohort. This variation is important for interpretation because it shows that even in classes where PBL is perceived positively, not all students achieve at the same level. In vocational entrepreneurship learning, outcomes can depend not only on the instructional model but also on students' prior experiences, motivation, and access to learning supports. Consequently, the outcome profile should be read as evidence of broadly improved attainment rather than uniform gains for every individual student.

The inferential results strengthen the claim that PBL is associated with improved PKK outcomes. The positive regression coefficient ($b = 0.460$) indicates that higher PBL scores correspond to higher predicted learning outcomes, consistent with the theoretical mechanism of PBL: problem orientation stimulates curiosity and relevance, structured inquiry builds understanding, collaboration supports knowledge construction, and reflection consolidates transferable reasoning (Widuri & Madiun, 2022). The significant t-test result ($p < 0.001$) provides statistical support for rejecting the null hypothesis of no effect, aligning with methodological guidance that the t-test can be used to assess the partial effect of a predictor within regression and that significance is indicated when p-values fall below 0.05 (Ghozali, 2018).

The strength of association ($R = 0.732$) is consistent with the growing empirical literature that PBL improves learning outcomes more effectively than conventional, lecture-dominant instruction by promoting active participation and deeper engagement. Experimental evidence indicates that PBL significantly increases students' learning outcomes compared with conventional methods and enhances conceptual understanding and motivation through active, collaborative, problem-focused learning (Nusi et al., 2024). Similarly, findings in secondary education contexts show that PBL improves critical thinking and conceptual mastery by enabling learners to connect theory to real situations more effectively than in teacher-centred classrooms (Fitriani et al., 2024). The present results therefore extend and contextualise these findings within vocational entrepreneurship learning, reinforcing the argument that PBL's learning mechanism is particularly suitable for practice-oriented subjects where students must apply concepts to complex, real-world tasks.

$R^2 = 0.536$ indicates that PBL explains 53.6% of variance in PKK outcomes, which is substantial for educational research where outcomes are typically shaped by multiple interacting influences. The magnitude suggests that the instructional model is a central driver of outcomes in this setting, but it also highlights that

nearly half of the outcome variance is explained by other influences. This balance supports a nuanced interpretation: PBL is impactful, yet its effectiveness may be amplified or constrained by individual and contextual conditions.

The remaining 46.4% unexplained variance invites discussion of factors beyond the instructional model. Educational achievement is not determined solely by pedagogy; it also reflects motivational, environmental, and socio-economic conditions that shape students' capacity to engage with learning opportunities. Motivation and persistence are commonly understood as internal drivers that influence students' willingness to invest effort in inquiry-oriented tasks, especially those requiring sustained investigation and product development. When motivation differs between students, those differences can translate into differences in participation quality, time-on-task, and thus learning outcomes even within the same classroom model.

External learning conditions may also shape outcomes, particularly in vocational contexts where materials, tools, and media are integral to skill development. Evidence suggests that learning facilities significantly affect students' outcomes; adequate classrooms, equipment, and supporting media can promote active participation, concentration, and improved achievement (Meliyana et al., 2023). For PKK learning under PBL, facilities can be especially influential because product-oriented tasks often require access to materials, design tools, and spaces for collaborative work. If facilities are limited, students may struggle to fully enact investigation and production stages even when the pedagogical design is sound.

Financial and programmatic supports are another potential source of outcome variation. Scholarship and assistance programmes have been reported to positively influence learning motivation and academic achievement by reducing economic burdens and enabling students to focus more consistently on study requirements (Gobel et al., 2023; Halid et al., 2025). In vocational schools, where students may face resource constraints that affect project completion or learning concentration, such supports may interact with PBL by increasing the feasibility of sustained engagement in project-based entrepreneurial tasks. Therefore, the unexplained variance in this study is not merely statistical residual; it plausibly represents meaningful educational conditions that warrant attention in implementation planning.

The results align with Indonesia's educational mandate that learning should be deliberately planned to develop learners' competencies and support their active participation in developing intellectual, moral, and practical potential (Law No. 20, 2003). They also align with the broader view that education serves to form competitive individuals through learning processes that extend beyond content transmission toward holistic development (Hermino, 2014). In practice, however, many classrooms remain dominated by lecturing and undifferentiated instruction that reduces student engagement and limits higher-order thinking, contributing to low outcomes (Wiguma Minat et al., 2022). The present findings suggest that PBL provides an operational pathway for moving from policy and theory to classroom

practice by specifying a staged, learner-centred process that embeds learning in authentic problems.

The indicator-level evidence reinforces this alignment. The high “problem orientation” score suggests that learning began with meaningful contexts, which increases relevance and invites student agency. High scores in “analysis and evaluation” indicate that reflection and evaluation were part of the learning cycle, supporting metacognitive development and transferability of learning strategies. These features are consistent with the pedagogical logic that students develop deeper understanding and more durable skills when learning involves active inquiry, collaboration, and reflective judgement rather than passive reception.

From a practical standpoint, the results support the integration of PBL as a routine instructional model in PKK, particularly because entrepreneurship education is inherently problem-centred and performance-oriented. Teachers can use contextual entrepreneurial problems to structure learning around opportunity identification, product design, business planning, and market analysis, thereby embedding conceptual learning within authentic task demands. The slightly lower indicator means for investigation guidance and product presentation, although still within the “Very Good” category, suggest that teachers may benefit from strengthening facilitation strategies in these stages. Enhanced scaffolding could include clearer investigation prompts, structured roles in group inquiry, and formative feedback cycles to support students in gathering information, testing ideas, and presenting products coherently.

School-level support is also implicated by the explanatory limits of the regression model. If facilities significantly shape the effectiveness of PBL, then improving entrepreneurship learning outcomes requires attention not only to pedagogy but also to learning infrastructure. Providing adequate tools, media, and spaces for collaborative product development can increase the quality and authenticity of PBL tasks, thereby supporting stronger psychomotor and applied outcomes. Moreover, partnerships and programmes that reduce resource constraints for students may strengthen sustained engagement in entrepreneurship projects, complementing PBL’s learning mechanism.

The findings should be interpreted with awareness of methodological boundaries. First, the study used a single-site design and a relatively small cohort ($N = 32$), which supports in-depth context-specific inference but limits generalisation to other vocational schools with different student characteristics or resource conditions. Second, the measurement of PBL implementation and learning outcomes relied substantially on student questionnaire responses, which, although validated and reliable, may reflect perception-based biases. Third, the regression model was intentionally simple, focusing on the direct influence of PBL on learning outcomes. While the R^2 value indicates strong explanatory power, it also implies that other factors not included in the model contribute meaningfully to outcomes.

Future research can build on these limitations by using multi-site samples to test the stability of the PBL–outcome relationship across different vocational

schools and by incorporating additional predictors such as motivation, facility quality, and external support. Mixed-methods designs could also deepen understanding of how specific PBL stages are enacted in PKK contexts and how teacher facilitation decisions shape student engagement and product quality. Finally, longitudinal designs could examine whether PBL influences not only short-term learning outcomes but also longer-term entrepreneurial competencies, such as opportunity recognition, resilience, and sustained innovation habits. Overall, the present study contributes evidence that PBL is a strong instructional driver of PKK learning outcomes in a public vocational school setting, while also highlighting that optimal results depend on supportive conditions that extend beyond instructional design alone.

Conclusion

This study demonstrates that the quality of problem-based learning implementation is strongly and positively associated with learning outcomes in Creative Products and Entrepreneurship at SMK Negeri 4 Gorontalo. The regression results indicate a positive slope, and the statistical test confirms that the relationship is significant, showing that students who experienced stronger problem-based learning processes tended to achieve higher outcomes. The descriptive patterns further suggest that both the learning model and student outcomes were rated very highly across key learning stages and across cognitive, affective, and psychomotor domains, indicating that contextual problem orientation, guided inquiry, collaborative work, and reflective evaluation can meaningfully support entrepreneurship-oriented competence development.

The main implication is that sustained and structured problem-based learning can function as a primary instructional driver for strengthening vocational students' mastery of entrepreneurial concepts, their learning dispositions, and their practical performance in product-oriented tasks. At the same time, the explanatory power of the model indicates that substantial outcome variance remains attributable to factors beyond the instructional model, implying that pedagogical improvement should be paired with supportive learning conditions such as adequate facilities and motivational supports.

By providing context-specific empirical evidence from an Indonesian public vocational school, this study contributes to the existing body of knowledge on student-centred pedagogy in vocational entrepreneurship education and strengthens the argument that problem-based learning is particularly appropriate for practice-oriented subjects. Future research may extend these findings through multi-school studies, inclusion of additional predictors such as motivation and facility quality, and longitudinal designs assessing whether problem-based learning effects persist in students' longer-term entrepreneurial competencies.

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