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Effect of problem-based learning integrated with Contextual Teaching and Learning on kitchen utensil learning outcomes

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ABSTRACT

This study aimed to examine the effect of the Problem-Based Learning (PBL) model integrated with Contextual Teaching and Learning (CTL) on students' cognitive learning outcomes in the Kitchen Utensil topic among Grade X Culinary students at SMK Negeri 3 Solok. A quantitative approach with a quasi-experimental non-equivalent control group design was employed. The sample consisted of 62 students divided into an experimental group (n = 31) and a control group (n = 31). Data were collected through pretest and posttest achievement tests and analyzed using descriptive statistics, Independent Samples t-test, Paired Samples t-test, N-Gain analysis, and Cohen's d effect size. The findings revealed a significant difference in posttest scores between the experimental and control groups ($t = 3.020$, $p = 0.004$). The experimental group achieved a higher mean score (79.44) than the control group (72.58). Furthermore, students in the experimental group demonstrated significant improvement from pretest to posttest ($t = -13.902$, $p < 0.001$), with an N-Gain score of 0.39 and a very large effect size ($d = 2.497$). The PBL-based CTL model was effective in improving students' cognitive learning outcomes and can serve as an innovative instructional approach in vocational culinary education.

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Introduction

Vocational education plays a strategic role in preparing graduates who possess both theoretical understanding and practical competencies required by the labor market (Butler et al., 2025; Galyean et al., 2025). In culinary vocational education, students are expected to master fundamental competencies before progressing to more complex food preparation and production activities. One of these competencies is the ability to identify, classify, select, and appropriately use kitchen utensils. Mastery of kitchen utensil knowledge is essential because improper understanding may affect efficiency, safety, and performance during culinary practice. However, observations in vocational learning environments indicate that students often memorize the names and functions of kitchen utensils without fully understanding their practical applications in authentic culinary situations. Consequently, learning outcomes in this topic frequently remain below expectations and may hinder the development of subsequent vocational competencies (Ghuttora et al., 2025).

One factor contributing to these learning challenges is the continued dominance of teacher-centered instructional practices in vocational classrooms. Although Direct Instruction can efficiently deliver factual information, it often limits students' opportunities to actively construct knowledge and apply concepts to workplace-related situations. As a result, students may experience difficulties when required to analyze

problems, select appropriate tools, and make decisions in authentic culinary contexts. Such limitations are inconsistent with current vocational education demands, which emphasize critical thinking, problem solving, and contextual application of knowledge. Previous studies have highlighted the importance of learning environments that actively engage students and promote meaningful learning experiences in order to improve vocational competence and learning engagement (Ansori et al., 2025; Patria et al., 2025).

Problem-Based Learning (PBL) has been widely recognized as an instructional model capable of promoting active learning through authentic problem-solving activities. The model encourages students to investigate problems, formulate solutions, collaborate with peers, and reflect on their learning experiences, thereby facilitating deeper conceptual understanding. In vocational education, PBL is particularly relevant because workplace tasks commonly require analytical thinking and practical decision-making skills. Previous studies have reported that PBL contributes positively to academic achievement, learning engagement, and the development of higher-order thinking skills across various educational contexts (Mahfud et al., 2025; Niklassen et al., 2025; Benavides et al., 2025; Wong et al., 2025). Furthermore, hospitality and culinary education research has demonstrated that problem-based instructional activities can improve learning effectiveness when students are confronted with realistic professional scenarios (Su, 2024).

In addition to PBL, Contextual Teaching and Learning (CTL) has been identified as an effective approach for helping students connect academic knowledge with real-life experiences. CTL emphasizes meaningful learning by relating instructional content to situations that students may encounter in their future professions. Within culinary education, contextual learning can facilitate students' understanding of how kitchen utensils are selected, utilized, and maintained in professional food-service environments. Previous studies have shown that CTL can enhance cognitive achievement, motivation, and learning retention because students perceive greater relevance between classroom learning and practical applications (Milliron et al., 2025; Thomas et al., 2025; Alrhmoun et al., 2025; Ozilgen et al., 2025). Evidence from vocational practice learning also indicates that CTL contributes positively to students' cognitive learning outcomes and practical understanding (TriLaksono et al., 2025).

Despite the documented effectiveness of PBL and CTL, several important gaps remain in the existing literature. First, most previous studies have examined PBL and CTL as independent instructional approaches rather than investigating their integration within a unified learning framework. Second, empirical studies focusing specifically on culinary vocational education remain limited, with much of the existing evidence originating from general education, STEM, entrepreneurship, health, or higher education settings (Krumholz et al., 2025; Noerper et al., 2025; Ngoumou et al., 2025). Third, limited evidence is available regarding how the combination of problem-solving processes and contextual learning experiences influences students' mastery of kitchen utensil competencies. Consequently, the potential synergistic effect of integrating PBL and CTL within vocational culinary instruction has not been sufficiently explored (Sinha & Mahato, 2025; Timalsina et al., 2025).

This study was conducted to address these gaps by examining the effectiveness of a Problem-Based Learning model integrated with Contextual Teaching and Learning in improving students' cognitive learning outcomes on the Kitchen Utensil topic among Grade X Culinary students at SMK Negeri 3 Solok. The novelty of this study lies in three aspects: the integration of PBL and CTL into a single instructional framework, the application of the integrated model within a specific vocational culinary competency that has received limited scholarly attention, and the evaluation of learning effectiveness using hypothesis testing, N-Gain analysis, and effect size measurements. Therefore, this study is expected to contribute both theoretically and practically to the advancement of vocational education pedagogy by providing empirical evidence regarding the effectiveness of integrating problem-based and contextual learning approaches in culinary learning environments (Jurado-Gonzalez et al., 2025; Troplini et al., 2025; Zick et al., 2025).

Method

This study employed a quantitative approach using a quasi-experimental Non-Equivalent Control Group Design to examine the effect of Problem-Based Learning (PBL) integrated with Contextual Teaching and Learning (CTL) on students' cognitive learning outcomes in the Kitchen Utensil topic. The population consisted of 94 Grade X Culinary students at SMK Negeri 3 Solok during the 2025/2026 academic year. Through cluster sampling, two classes with comparable academic characteristics were selected, resulting in 62 students divided equally into an experimental group (n = 31) and a control group (n = 31). Pretest results showed no significant difference between groups ($p = 0.449$), indicating equivalent initial abilities. The experimental group received PBL-CTL instruction, while the control group was taught using Direct Instruction.

The intervention was conducted over six learning sessions. In the experimental group, students learned through PBL stages integrated with CTL principles, including identifying authentic culinary problems, conducting group investigations, discussing solutions, and presenting findings related to kitchen utensil use and management. Contextual learning was applied by linking learning materials to real workplace situations in professional kitchens. In contrast, the control group received conventional teacher-centered instruction consisting of explanation, demonstration, guided practice, and classroom discussion. A posttest was administered to both groups after the intervention.

Data were collected using a cognitive achievement test consisting of 40 multiple-choice items developed based on curriculum learning outcomes and Bloom's taxonomy (C1–C6). Content validity was evaluated by experts in vocational and culinary education, while item analysis retained 35 valid items for the final instrument. The reliability test yielded a Cronbach's Alpha coefficient of 0.89, indicating high reliability. Data were analyzed using SPSS version 27 through descriptive statistics, Shapiro–Wilk normality tests, Levene's homogeneity tests, Independent Samples t-tests, and Paired Samples t-tests. N-Gain, gain score, Cohen's d, and Hedges' g analyses were also performed to evaluate learning improvement and practical intervention effects.

Results and Discussions

This study was conducted to investigate the effect of the Problem-Based Learning (PBL) model integrated with Contextual Teaching and Learning (CTL) on students' cognitive learning outcomes in the Kitchen Utensil topic among Grade X Culinary students at SMK Negeri 3 Solok. The analysis was based on data collected from 62 students, consisting of 31 students in the experimental group and 31 students in the control group. The experimental group received instruction through the PBL-based CTL model, whereas the control group was taught using the Direct Instruction approach. The data analysis included descriptive statistics, assumption testing, hypothesis testing, N-Gain analysis, and effect size analysis. Descriptive statistics were used to describe students' learning achievement before and after the intervention, while inferential statistics were employed to determine the significance of differences between groups and the magnitude of learning improvement. The results are presented sequentially, including participant characteristics, pretest and posttest analyses, hypothesis testing, effect size estimation, and N-Gain analysis.

Table 1. Distribution of Research Participants

Group	Number of Students (n)	Percentage (%)
Experimental Class (PBL-CTL)	31	50.0
Control Class (Direct Instruction)	31	50.0
Total	62	100.0

The study involved 62 tenth-grade students enrolled in the Culinary Expertise Program at SMK Negeri 3 Solok City. The participants were equally distributed into two groups, consisting of 31 students in the experimental class and 31 students in the control class. This balanced distribution ensured comparable sample sizes between groups and strengthened the validity of the comparative analysis conducted in this study.

Table 2. Descriptive Statistics of Pretest Scores

Group	n	Minimum	Maximum	Mean	SD
Experimental Class	31	47.5	80.0	66.37	8.70
Control Class	31	40.0	77.5	64.60	9.60

Table 2 presents the descriptive statistics of students' pretest scores before the implementation of the learning intervention. The experimental class obtained a mean score of 66.37 (SD = 8.70), while the control class achieved a mean score of 64.60 (SD = 9.60). The difference between the two groups was only 1.77 points, indicating relatively similar prior knowledge regarding the kitchen utensil topic. Furthermore, the comparable standard deviations suggest that the variability of students' initial achievement was relatively similar across both groups.

Table 3. Normality Test of Pretest Scores (Shapiro–Wilk)

Group	Statistic	df	Sig.
Experimental Class	0.940	31	0.085
Control Class	0.934	31	0.056

The Shapiro–Wilk normality test showed significance values of 0.085 for the experimental class and 0.056 for the control class. Since both values exceeded the significance level of 0.05, the pretest data were normally distributed. Therefore, the assumption of normality required for parametric statistical analysis was fulfilled.

Table 4. Homogeneity Test of Pretest Scores

Levene Statistic	df1	df2	Sig.
0.386	1	60	0.537

The Levene's Test revealed a significance value of 0.537, which was higher than 0.05. This result indicates that the variances of the experimental and control groups were homogeneous. Consequently, both groups possessed equivalent variance characteristics and met the assumption for conducting an Independent Samples t-test.

Table 5. Independent Samples t-Test of Pretest Scores

Variable	t	df	Sig. (2-tailed)	Mean Difference
Pretest Scores	0.762	60	0.449	1.774

The Independent Samples t-test produced a significance value of 0.449, which exceeded the threshold of 0.05. Therefore, no statistically significant difference was found between the pretest scores of the experimental and control groups. This finding confirms that both groups had equivalent initial learning abilities before the instructional treatment was implemented.

Table 6. Summary of Posttest Comparison Between Experimental and Control Groups

Variable	Experimental Class (n=31)	Control Class (n=31)	Statistical Test
Mean ± SD	79.44 ± 8.48	72.58 ± 9.36	t = 3.020
Minimum–Maximum	65.0–95.0	45.0–87.5	df = 60
Shapiro–Wilk Sig.	0.133	0.134	Normal Distribution
Levene's Test Sig.			0.869
Mean Difference			6.855
Sig. (2-tailed)			0.004*
95% CI			2.315–11.394
Cohen's d			0.767
Hedges' g			0.758
Glass's Δ			0.732
Effect Interpretation			Moderate-to-Large
Mean N-Gain	0.39	0.22	Moderate vs. Low

*Significant at $p < 0.05$

The posttest analysis demonstrated that students in the experimental class achieved higher learning outcomes than those in the control class. The experimental group obtained a mean score of 79.44 (SD = 8.48), while the control group achieved a mean score of 72.58 (SD = 9.36), resulting in a mean difference of 6.855 points. The Shapiro–Wilk and Levene's tests confirmed that the assumptions of normality and homogeneity were satisfied. The Independent Samples t-test revealed a statistically significant difference between groups ($t = 3.020$, $p = 0.004$), indicating that the PBL-based CTL model was more effective than Direct Instruction. Furthermore, the effect size analysis showed moderate-to-large effects (Cohen's $d = 0.767$; Hedges' $g = 0.758$), suggesting that the observed improvement was not only statistically significant but also educationally meaningful. The N-Gain results further supported this finding, with the experimental class achieving a moderate gain (0.39) compared to the low gain observed in the control class (0.22).

Table 7. Summary of Learning Improvement in the Experimental Group

Variable	Pretest	Posttest	Statistical Test
Mean ± SD	66.37 ± 8.70	79.44 ± 8.48	t = -13.902
Sample Size (n)	31	31	df = 30
Mean Difference		13.065	p < 0.001*
Correlation (r)		0.815	p < 0.001
Cohen's d			-2.497
Hedges' g	-	-	-2.465
Effect Interpretation	-	-	Very Large

*Significant at $p < 0.05$

The within-group analysis indicated substantial learning improvement among students who participated in the PBL-based CTL intervention. The mean score increased from 66.37 in the pretest to 79.44 in the posttest, representing an improvement of 13.07 points. A strong positive correlation was observed between pretest and posttest scores ($r = 0.815$, $p < 0.001$), suggesting consistency in students' performance rankings over time. The paired samples t-test confirmed a highly significant improvement in learning outcomes following the intervention ($t = -13.902$, $p < 0.001$). Moreover, the effect size analysis yielded very large values (Cohen's $d = -2.497$; Hedges' $g = -2.465$), indicating that the PBL-based CTL model exerted a substantial influence on students' cognitive achievement. These findings provide strong evidence that the instructional model effectively enhanced students' understanding of kitchen utensil learning materials.

The findings demonstrated that students in the experimental and control groups possessed comparable initial abilities prior to the intervention, as reflected by the non-significant difference in pretest scores. This condition strengthens the internal validity of the study because the improvements observed after the intervention are more likely associated with the learning model implemented rather than differences in prior knowledge. In vocational education, establishing equivalent baseline conditions is essential because students' initial competencies may substantially influence subsequent learning achievement. Therefore, the comparable pretest results provide a strong foundation for evaluating the effectiveness of the PBL-based CTL model in culinary learning (Jurado-Gonzalez et al., 2025; Su, 2024).

Following the intervention, students who learned through the PBL-based CTL model achieved significantly higher posttest scores than those who received Direct Instruction. The superiority of the experimental group can be explained by the characteristics of PBL and CTL, which encourage students to actively engage with authentic culinary problems rather than merely receive information from teachers. Through problem identification, collaborative discussion, and contextual exploration, students developed a deeper understanding of kitchen utensil concepts and their practical applications in professional kitchen environments. This finding supports previous studies reporting that active and contextual learning approaches improve conceptual understanding and learning achievement more effectively than conventional instruction (Berk & Gülcü, 2024; TriLaksono et al., 2025; Bardoe et al., 2023; Wibowo et al., 2026).

The significant improvement observed within the experimental group indicates that the integration of PBL and CTL successfully facilitated meaningful learning processes. Students were encouraged not only to recognize the functions and classifications of kitchen utensils but also to analyze their relevance in authentic culinary situations. Such learning experiences are particularly important in vocational education because workplace competence requires the ability to connect theoretical knowledge with practical decision-making. The findings therefore extend previous research by demonstrating that the integration of problem-solving and contextual learning strategies can effectively support cognitive development in culinary vocational education (Sristy, 2024; Sumiyati et al., 2025; Bodrug, 2025; Maba et al., 2025).

The effect size analysis further revealed that the educational impact of the intervention was meaningful in practical terms. The between-group effect size (Cohen's $d = 0.767$) indicates a moderate-to-large effect, suggesting that the observed differences were not merely statistically significant but also educationally relevant. Although the within-group effect size was very large, this finding should be interpreted cautiously because effect sizes may be influenced by sample characteristics, score variability, and the duration of the intervention. Nevertheless, the consistently higher achievement of the experimental group confirms that integrating PBL and CTL provides added value beyond traditional teacher-centered instruction (Conner, 2021; Cook, 2020).

Additional evidence of effectiveness was provided by the N-Gain analysis, which showed a moderate gain (0.39) in the experimental group compared with a low gain (0.22) in the control group. While the gain category was not exceptionally high, the result indicates that the intervention generated meaningful conceptual growth within a relatively limited implementation period. This finding suggests that longer intervention durations or broader integration with practical laboratory activities may further enhance learning outcomes. From a practical perspective, the study provides evidence that vocational teachers can adopt the PBL-based CTL model as an alternative instructional strategy to improve students' cognitive achievement while simultaneously strengthening the connection between classroom learning and professional culinary practice (Berk & Gülcü, 2024; TriLaksono et al., 2025).

Conclusions

The findings of this study demonstrate that the implementation of the Problem-Based Learning (PBL) model integrated with Contextual Teaching and Learning (CTL) significantly improves students' cognitive learning outcomes in the Kitchen Utensil topic among Grade X Culinary students at SMK Negeri 3 Solok. Students who participated in the PBL-based CTL learning activities achieved significantly higher posttest scores than those

who learned through Direct Instruction. In addition, the experimental group showed substantial learning improvement from pretest to posttest, supported by a moderate N-Gain score and a very large effect size. These results indicate that integrating problem-solving activities with contextual learning experiences creates a more meaningful and effective learning environment, enabling students to better understand and apply culinary concepts. Therefore, the PBL-based CTL model can be considered an effective and innovative instructional approach for enhancing cognitive achievement in vocational culinary education.

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