Innovating martial arts pedagogy: the effect of problem-based learning on cognitive, motivational, and skill development in Pencak Silat

Innovando la pedagogía de las artes marciales: el efecto del aprendizaje basado en problemas sobre el desarrollo cognitivo, motivacional y de habilidades en el Pencak Silat

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Abstract

Introduction: Mastering kicking techniques in Pencak Silat requires integration of cognitive understanding, psychomotor execution, and high motivation. Conventional teaching often inadequately addresses all three domains simultaneously.
Objective: This study examined the effectiveness of a Problem-Based Learning (PBL) model in enhancing cognitive achievement, learning motivation, and skill performance in Pencak Silat.
Methodology: A quasi-experimental pretest–posttest control group design was employed. Ninety-nine undergraduates participated: 48 in the experimental group received PBL instruction, and 51 in the control group underwent conventional teaching. Instruments were validated (Aiken's V = 0.82–0.95) and reliable (α = 0.79–0.91). Paired-sample and independent t-tests were used to analyze within- and between-group differences, with Cohen's d assessing effect sizes.
Results: The experimental group showed significant post-test improvements in cognitive achievement ($t(97) = 3.416$, $p = 0.001$, $d = 0.689$), learning motivation ($t(97) = 12.069$, $p < 0.001$, $d = 2.461$), and skill performance ($t(97) = 9.262$, $p < 0.001$, $d = 1.851$). Paired-sample tests confirmed robust within-group gains, while the control group exhibited minimal cognitive change ($p = 0.211$).
Discussion: PBL fostered active engagement, reflective thinking, and skill mastery, consistent with constructivist and Self-Determination Theory principles. Motivation and psychomotor improvements highlight the model's holistic effect on martial arts learning.
Conclusions: PBL significantly enhances cognitive, motivational, and psychomotor outcomes, providing an effective alternative to conventional teaching. Limitations include single-site implementation, short intervention duration, and partial reliance on subjective measures; future studies should examine long-term effects and multi-institutional replication.

Keywords

Pencak Silat, problem-based learning, cognitive achievement, learning motivation, psychomotor skills, martial arts pedagogy.

Resumen

Introducción: El dominio de las técnicas de patada en Pencak Silat requiere la integración de comprensión cognitiva, ejecución psicomotriz y alta motivación. La enseñanza convencional a menudo no optimiza simultáneamente estos tres aspectos.
Objetivo: Este estudio evaluó la efectividad del modelo de Aprendizaje Basado en Problemas (ABP) para mejorar el rendimiento cognitivo, la motivación de aprendizaje y las habilidades técnicas en estudiantes de Pencak Silat.
Metodología: Se empleó un diseño cuasi-experimental con pretest y postest y grupo de control. Participaron 99 estudiantes universitarios: 48 en el grupo experimental recibieron instrucción mediante ABP y 51 en el grupo control recibieron enseñanza convencional. Los instrumentos fueron validados (V de Aiken = 0,82–0,95) y confiables (α = 0,79–0,91). Se realizaron pruebas t para muestras pareadas e independientes, y se calcularon tamaños de efecto con Cohen's d.
Resultados: El grupo experimental mostró mejoras significativas en postest en rendimiento cognitivo ($t(97) = 3,416$, $p = 0,001$, $d = 0,689$), motivación de aprendizaje ($t(97) = 12,069$, $p < 0,001$, $d = 2,461$) y habilidades técnicas ($t(97) = 9,262$, $p < 0,001$, $d = 1,851$). Las pruebas pareadas confirmaron ganancias significativas dentro del grupo, mientras que el grupo control mostró cambios cognitivos mínimos ($p = 0,211$).
Discusión: El ABP promovió participación activa, pensamiento reflexivo y dominio de habilidades, en línea con los principios de Constructivismo y la Teoría de la Autodeterminación. Los incrementos en motivación y habilidades psicomotrices evidencian un efecto integral en el aprendizaje de artes marciales.
Conclusiones: El ABP mejora significativamente los resultados cognitivos, motivacionales y psicomotrices, constituyendo una alternativa eficaz a la enseñanza convencional. Las limitaciones incluyen un solo sitio de estudio, corta duración de la intervención y uso parcial de medidas subjetivas; investigaciones futuras deberían explorar efectos a largo plazo y replicación en múltiples instituciones.

Palabras clave

Pencak Silat, aprendizaje basado en problemas, rendimiento cognitivo, motivación de aprendizaje, habilidades psicomotoras, pedagogía de artes marciales.

Introduction

Pencak Silat, a traditional Indonesian martial art, reflects a holistic integration of physical discipline, mental resilience, and moral integrity rooted in Indonesia's cultural identity (Sulfa, Lubis, & Rihatno, 2024). Beyond its function as a combat system, it embodies a philosophical framework that emphasizes bodily mastery, moral conduct, and spiritual balance (Hariono, Aryanto, Herwin, & Nugroho, 2024). Core values such as respect, discipline, humility, and responsibility remain central to its practice, serving as ethical guidelines while transmitting cultural heritage across generations (Ihsan et al., 2024). Within higher education, Pencak Silat is offered as a compulsory subject in many faculties of sports science, aiming to cultivate students' psychomotor proficiency, cognitive understanding, and cultural appreciation (Nugroho, Irianto, Lismadiana, Hariono, & Widodo, 2024).

Despite its cultural and educational importance, instructional practices in Pencak Silat classrooms remain predominantly teacher-centered. Lecturers commonly employ repetitive demonstrations and imitation-based drills, limiting opportunities for inquiry, reflective thinking, and contextual problem-solving (Divayana, Suwiwa, & Mashuri, 2024). To verify this issue, preliminary classroom observations were conducted over four instructional meetings (each lasting 100 minutes) in April 2025. A structured observation sheet adapted from Divayana et al., (2024) was used, containing indicators such as instructional clarity, questioning strategies, feedback patterns, student participation, and problem-solving prompts. Two trained observers independently documented teaching methods and learner behaviors using a systematic, non-participant procedure, allowing consistency and reducing observer bias. The observations showed predominant drill-based instruction, low student engagement, and minimal analytical discussion, reinforcing the need for a pedagogical shift.

In contemporary higher education, student-centered instructional approaches such as Problem-Based Learning (PBL) have been widely recognized for their potential to enhance autonomy, critical thinking, and deep learning (Sakdiah & Syahrani, 2022; Xie & Derakhshan, 2021). PBL is particularly well aligned with the nature of Pencak Silat training, as both emphasize experiential learning, self-reflection, contextual reasoning, and adaptive problem-solving. The dynamic and situational characteristics of martial arts require students to analyze challenges, adjust techniques, and collaboratively identify effective solutions—learning behaviors that PBL inherently cultivates (Jang, 2023; Liu & Pásztor, 2022; Razak et al., 2022).

Theoretically, the implementation of PBL in Pencak Silat instruction is grounded in Constructivist Learning Theory and Self-Determination Theory (SDT). Constructivism asserts that learners construct knowledge through active engagement, reflection, and contextual interpretation (Shah, 2019). In martial arts learning, students must not only imitate a technique but also derive understanding from feedback, situational variations, and experiential refinement. SDT posits that optimal motivation emerges when learners experience autonomy, competence, and relatedness (Niemiec & Ryan, 2009). PBL organically supports these psychological needs by positioning students as autonomous problem-solvers, offering mastery-oriented challenges, and encouraging collaborative interaction. Integrating both theoretical perspectives provides a strong conceptual rationale for applying PBL to Pencak Silat: it aligns traditional martial values with contemporary, evidence-based learning principles.

Although several studies have explored Pencak Silat instruction (e.g., Divayana et al., 2024; Nuraisyah, Wibowo, & Rofi, 2025), existing research remains largely descriptive and fragmented. Prior studies have emphasized media development or isolated skills without embedding them in a comprehensive pedagogical model. Methodological limitations are also evident, such as reliance on non-experimental designs, absence of motivation-related measures, and lack of examination of psychological mechanisms (e.g., autonomy, error correction strategies) underlying skill acquisition. Consequently, the literature provides limited insight into how structured instructional models can enhance cognitive, motivational, and psychomotor outcomes simultaneously in martial arts learning environments.

Kicking techniques were selected as the instructional focus due to their high biomechanical and coordination demands in beginner-to-intermediate Pencak Silat training. Errors in kicking technique constitute more than 60% of technical mistakes among novice students (Nuraisyah et al., 2025). Beyond these biomechanical considerations, kicking tasks also require continuous error diagnosis, balance control, tactical judgment, and focused motivation during repetitive practice. Pedagogically, kicking techniques

create rich conditions for problem analysis and reflective adjustment, making them an appropriate domain for evaluating whether PBL stimulates higher-order reasoning during complex motor performance.

Prior empirical evidence further supports the potential of PBL to enhance multidimensional learning outcomes. Studies across skill-based and movement-based education show that PBL can improve motivation, analytical thinking, and performance (Belland, Gu, Kim, Turner, & Weiss, 2019; Hardiansyah et al., 2025; Purnomo et al., 2024). However, no study in martial arts pedagogy has systematically integrated PBL principles into a structured instructional model while measuring their effects on cognitive, motivational, and psychomotor achievement. This gap underscores the need for empirical validation of student-centered instructional designs within martial arts contexts.

Based on this analysis, two major research gaps are identified:

1. The lack of a theoretical framework explaining how PBL principles can be systematically applied to martial arts education, particularly Pencak Silat.
2. The absence of empirical studies evaluating the effectiveness of PBL-based instruction in enhancing cognitive, motivational, and skill performance simultaneously.

To address these gaps, the present study aims to develop and evaluate a PBL-based instructional model for Pencak Silat kicking techniques. This model is designed to promote active engagement, contextual reasoning, and practical mastery while preserving the cultural philosophy inherent in martial arts learning.

Research Hypotheses

H1: The PBL-based instructional model significantly improves students' cognitive achievement compared to conventional methods.

H2: The PBL-based instructional model significantly enhances students' learning motivation.

H3: The PBL-based instructional model significantly improves students' kicking skill performance.

H4: The effects of the PBL-based instructional model demonstrate moderate-to-large magnitudes across learning domains.

Theoretically, this study extends the application of student-centered instructional frameworks into culturally embedded sports pedagogy. Practically, it contributes an evidence-based instructional model that can be adapted in martial arts curricula in higher education, thereby supporting educational innovation and the preservation of Indonesian martial heritage.

Method

Participants

The participants were undergraduate students enrolled in the Physical Education, Health, and Recreation program at Universitas Muhammadiyah Kalimantan Timur, taking the Pencak Silat course during the even semester of the 2024/2025 academic year. Two intact classes with comparable size and demographic characteristics were selected through purposive sampling:

Experimental group: 48 students (29 males, 19 females) received instruction using a Problem-Based Learning (PBL) model.

Control group: 51 students (33 males, 18 females) were taught using conventional demonstration–practice–feedback methods, emphasizing repetition and instructor correction.

A priori power analysis using G*Power 3.1 software indicated that a minimum of 45 participants per group was required to detect a medium effect size (Cohen's d = 0.5) at $\alpha = 0.05$ and power = 0.80. The total sample of 99 students thus exceeded this minimum, ensuring adequate statistical power. Pretest comparisons confirmed baseline equivalence between groups ($p > 0.05$). Participation was voluntary, and all students provided written informed consent in accordance with university ethical standards.

Prior martial arts experience, weekly physical activity levels, and injury history were assessed via questionnaire. Students with more than one year of formal martial arts experience were excluded. The same certified lecturer taught both groups to minimize instructor effects.

Research Design

This study employed a quasi-experimental design with a non-equivalent pretest–posttest control group. Random assignment was not feasible due to the use of intact classes. The study formed part of a broader Research and Development (R&D) process guided by the ADDIE model (Analysis, Design, Development, Implementation, Evaluation).

Development phase: Focused on the Design and Implementation stages of the ADDIE model to develop a PBL-based instructional model for teaching Pencak Silat kicking techniques.

Experimental phase: Evaluated the effectiveness of the developed model compared with conventional teaching methods.

Both experimental and control groups completed pretest and posttest assessments over eight instructional sessions, measuring cognitive achievement, learning motivation, and psychomotor performance.

Ethical Approval

Ethical clearance was obtained from the Research Ethics Committee, Faculty of Sports Science, Universitas Muhammadiyah Kalimantan Timur (Approval No. 309/KET/FKIP.2/C.3/B/2025). Participation was voluntary, and participants were informed of the study procedures, confidentiality, and the right to withdraw at any time without penalty.

Development Procedure

The PBL-based instructional model was developed according to the ADDIE framework:

1. Analysis: Identification of learning needs, instructional challenges, and learner characteristics through observation and instructor interviews.
2. Design: Construction of PBL syntax, emphasizing problem orientation, group investigation, presentation, reflection, and feedback.
3. Development: Preparation of instructional materials and teaching media (videos, diagrams), as well as evaluation instruments. Expert validation involved four Ph.D. lecturers in sports pedagogy and two IPSI-certified Pencak Silat coaches.
4. Implementation: Application of the PBL model in the experimental class, with fidelity checks using an observation checklist. The control class continued conventional instruction.
5. Evaluation: Formative assessments were conducted after each session, followed by summative evaluation through pretest–posttest comparisons.
6. Expert validation: Items were evaluated for relevance, clarity, representativeness, and alignment with learning objectives using a 4-point scale. Aiken's V values ranged from 0.82 to 0.95. Inter-rater reliability for cognitive and motivation instruments was 0.86 and 0.91, respectively.

The detailed syntax of the developed PBL model is presented in Table 1.

Table 1. Syntax of the Problem-Based Learning (PBL) Model

Stage	Lecturer Activities	Student Activities
Problem Orientation	Presents learning objectives and situational problems using media (videos, simulations).	Listens attentively and identifies problem elements.
Organization of Learning Tasks	Divides students into small groups for collaborative problem-solving.	Discusses causes, formulates questions, proposes solutions.
Independent/Group Investigation	Guides research via literature, video analysis, and practical exploration.	Seeks information, conducts trials, engages in discussion.
Development and Presentation of Results	Facilitates group presentations and practical demonstrations.	Presents solutions and demonstrates kicking techniques.
Analysis and Evaluation	Provides feedback, clarifies concepts, motivates learners.	Reflects, evaluates, revises understanding based on feedback.

Instrument

Three validated instruments measured study variables:

1. Cognitive Learning Outcomes Test: 10 multiple-choice items on types of kicks, safety principles, error identification, and corrective strategies. Validity: Aiken's V = 0.85; Reliability: α = 0.81.
2. Learning Motivation Questionnaire: 20 Likert-scale items assessing effort, attention, persistence, enthusiasm, and optimism. Validity: Aiken's V = 0.89; Reliability: α = 0.90.
3. Psychomotor Skill Observation Rubric: Five indicators (accuracy, balance, control, height adjustment, speed). Validity: Aiken's V = 0.92; Inter-rater reliability: 0.88.

Table 2. Research Instrument Blueprint

Variable	Indicator	No. of Items / Scale	Reliability	Validity (Aiken's V)
Cognitive Achievement	Types and principles of kicking	10 items	α = 0.81	0.85
Learning Motivation	Effort, engagement, persistence, enthusiasm, optimism	20 items	α = 0.90	0.89
Psychomotor Skills	Accuracy, control, balance, speed, and form	5 criteria (score 1–4)	rater agreement = 0.88	0.92

Procedures to Minimize Bias

Several procedural safeguards were implemented to enhance internal validity:

1. Rater Blinding: Psychomotor performance assessed by two independent IPSI-certified judges blind to group allocation.
2. Fidelity Checks: Observers ensured the PBL syntax was fully implemented, while the control group maintained standard instruction.
3. Instructor Consistency: The same instructor taught both groups to avoid confounding effects.
4. Baseline Equivalence: Pretest comparisons confirmed no significant differences between groups ($p > 0.05$).

Data Analysis

Data were analyzed using SPSS 27.

- Descriptive statistics: Mean, SD, range.
- Inferential statistics:
  - Paired Samples t-Test for within-group pretest–posttest changes.
  - Independent Samples t-Test for posttest comparisons between groups.
  - Cohen's d for effect size (0.2 small, 0.5 medium, 0.8 large).
- Assumption testing: Normality (Shapiro–Wilk) and homogeneity of variance (Levene's test, $p > 0.05$).
- Significance level: $\alpha = 0.05$.

Results

Before conducting the inferential statistical analyses, descriptive statistics were computed to provide an overview of the participants' performance in both the experimental and control groups. These descriptive values allow for an initial comparison of pre-test and post-test scores, facilitating a clearer understanding of the magnitude and direction of change across the measured variables. Table 3 shows the pretest and posttest means and standard deviations for both groups. [ADD] Preliminary analysis confirmed that both groups started from similar baselines, ensuring fair posttest comparisons.

Table 3. Descriptive Statistics of Pre-test and Post-test Scores in Experimental and Control Groups

Variable	Group		N	Mean	SD
Cognitive Achievement	Pretest	Experimental	48	61.25	15.25
		Control	51	62.55	14.68
	Posttest	Experimental	48	73.33	11.73
		Control	51	64.31	14.32
Learning Motivation	Pretest	Experimental	48	2.40	0.44
		Control	51	2.44	0.39
	Posttest	Experimental	48	3.40	0.28
		Control	51	2.62	0.35
Skill Performance	Pretest	Experimental	48	12.19	2.17
		Control	51	12.51	1.86
	Posttest	Experimental	48	16.56	1.57
		Control	51	14.02	1.14

The descriptive statistics in Table 3 indicate that, prior to the intervention, the experimental and control groups exhibited relatively comparable baseline performance across all three domains—cognitive achievement, learning motivation, and skill performance—suggesting initial equivalence between groups. Specifically, the experimental group's pre-test mean for cognitive achievement was 61.25 (SD = 15.25), slightly lower than the control group's 62.55 (SD = 14.68). Learning motivation scores were also closely matched, with means of 2.40 (SD = 0.44) and 2.44 (SD = 0.39) for the experimental and control groups, respectively. Similarly, pre-test skill performance averages were 12.19 (SD = 2.17) for the experimental group and 12.51 (SD = 1.86) for the control group, reinforcing the absence of substantial pre-intervention differences.

Following the intervention, the experimental group demonstrated substantial improvements in all measured domains, clearly outperforming the control group. Post-test cognitive achievement increased to a mean of 73.33 (SD = 11.73) in the experimental group, compared to 64.31 (SD = 14.32) in the control group. Learning motivation also showed a marked increase in the experimental group, with a post-test mean of 3.40 (SD = 0.28), while the control group's mean remained relatively low at 2.62 (SD = 0.35). Skill performance exhibited a similar pattern, rising sharply to 16.56 (SD = 1.57) in the experimental group, compared with 14.02 (SD = 1.14) in the control group. These results suggest that the intervention had a positive and measurable effect on participants' cognitive, motivational, and skill-based outcomes.

Normality Test (Shapiro–Wilk)

Prior to performing parametric statistical analyses, the assumption of data normality was examined using the Shapiro–Wilk test, as it is particularly suitable for small to moderate sample sizes and provides robust detection of deviations from normality. The test was conducted separately for the post-test scores of the experimental and control groups across the cognitive, motivation, and skill domains. A *p*-value greater than 0.05 indicates that the data distribution does not significantly deviate from normality. As presented in Table 4, all *p*-values exceeded the 0.05 threshold, confirming that the assumption of normality was satisfied for all measured variables.

Table 4. Shapiro-Wilk Test for Normality

Variable	Group		p-value
Cognitive Achievement	Pretest	Experimental	0.337
		Control	0.324
	Posttest	Experimental	0.207
		Control	0.214
Learning Motivation	Pretest	Experimental	0.243
		Control	0.305
	Posttest	Experimental	0.316
		Control	0.316
Skill Performance	Pretest	Experimental	0.202
		Control	0,371
	Posttest	Experimental	0.269
		Control	0.425

Prior to conducting inferential analyses, the normality of the score distributions was examined using the Shapiro–Wilk test, as summarized in Table 4. The results indicated that all p-values for both the experimental and control groups, across pre-test and post-test assessments in cognitive achievement,

learning motivation, and skill performance, exceeded the conventional alpha threshold of 0.05. Specifically, for cognitive achievement, p-values ranged from 0.207 to 0.337; for learning motivation, from 0.243 to 0.316; and for skill performance, from 0.202 to 0.425. These findings provide statistical evidence that the data for each variable conformed to the assumption of normal distribution, thereby justifying the use of parametric tests in subsequent analyses.

Homogeneity of Variance (Levene's Test)

Following the confirmation of data normality, the assumption of homogeneity of variances between the experimental and control groups was examined using Levene's Test. This test assesses whether the variances in the compared groups are statistically equal, which is a prerequisite for conducting independent *t*-tests in parametric analysis. A *p*-value greater than 0.05 indicates that the variances are homogeneous. The results of this test are presented in Table 5.

Table 5. Levene's Test for Homogeneity

Variable	F	p-value
Cognitive Achievement	1.222	0.272
Learning Motivation	1.631	0.112
Skill Performance	1.044	0.315

The homogeneity of variance assumption was assessed using Levene's test, as presented in Table 5. The analysis revealed that all *p*-values were greater than the 0.05 significance level, with values of 0.272 for cognitive achievement, 0.112 for learning motivation, and 0.315 for skill performance. These results indicate that the variances between the experimental and control groups were statistically equivalent across all measured outcomes. Taken together with the normality results from the Shapiro–Wilk test, these findings confirm that the dataset met the parametric assumptions necessary for conducting independent samples *t*-tests in the subsequent inferential analysis.

Paired Samples t-Test – Experimental Group

Paired samples t-tests were conducted to evaluate within-group improvements in the experimental group after the PBL intervention. Pre-test and post-test scores for cognitive achievement, learning motivation, and skill performance are presented in Table 6.

Table 6. Paired Samples Test – Experimental Group

Pair	Mean Difference	SD	SE	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Pre–Post Cognitive	-12.0833	14.4338	2.0833	-16.274	-7.892	-5.800	47	.000
Pre–Post Motivation	-0.9917	0.5000	0.0722	-1.137	-0.846	-13.740	47	.000
Pre–Post Skill	-4.3750	3.0571	0.4413	-5.263	-3.487	-9.915	47	.000

Significant improvements were observed across all variables ($p < .001$). Motivation exhibited the largest within-group gain ($\Delta M = 0.99$), reflecting enhanced engagement, persistence, and autonomy. Cognitive achievement improved by approximately 12 points (~15% from baseline), indicating meaningful advancement in understanding Pencak Silat techniques and safety principles. Skill performance also showed substantial improvement in accuracy and execution.

Paired Samples t-Test – Control Group

Paired samples t-tests for the control group, which received conventional demonstration–practice instruction, are presented in Table 7.

Table 7. Paired Samples Test – Control Group

Pair	Mean Difference	SD	SE	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Pre–Post Cognitive	-1.7647	9.9410	1.3920	-4.561	1.031	-1.268	50	.211
Pre–Post Motivation	-0.1804	0.2775	0.0389	-0.258	-0.102	-4.642	50	.000
Pre–Post Skill	-1.5098	2.0820	0.2915	-2.095	-0.924	-5.179	50	.000

Minor gains were observed in motivation and skill performance, whereas cognitive gains were non-significant (p = .211). This indicates that conventional methods have limited effectiveness in enhancing conceptual understanding, engagement, or self-regulated learning.

To account for multiple comparisons (three dependent variables), a Bonferroni-adjusted alpha of 0.017 (0.05/3) was applied; all significant results remained significant under this threshold.

Independent Samples t-Test

An independent samples t-test was conducted to compare post-test scores between experimental (PBL) and control groups. Results are shown in Table 8.

Table 8. Independent t-Test Results for Post-test Scores

Variable	t	df	p-value	Mean Difference	95% CI Lower	95% CI Upper
Cognitive Achievement	3.416	97	0.001	9.02	3.78	14.26
Learning Motivation	12.069	97	0.000	0.77	0.65	0.90
Skill Performance	9.262	97	0.000	2.54	2.00	3.09

All post-test scores were significantly higher in the experimental group. Cognitive achievement improved by ~9 points (15% from baseline), confirming meaningful conceptual gains. Learning motivation showed a very large effect, indicating substantial increases in engagement, persistence, and autonomy. Skill performance was also significantly enhanced, reflecting improved motor execution and accuracy.

These results demonstrate that the PBL model is more effective than conventional instruction across cognitive, motivational, and psychomotor domains.

Effect Size Analysis (Cohen's d)

To quantify the practical significance of the observed differences, effect sizes were calculated using Cohen's d for each dependent variable. Effect size provides an estimate of the magnitude of change independent of sample size, complementing the statistical significance results obtained from t-tests. The results are summarized in Table 9.

Table 9. Effect Size (Cohen's d)

Variable	Cohen's d	Interpretation	Educational Implication
Cognitive Achievement	0.689	Medium	15% gain from baseline, indicating moderate conceptual improvement.
Learning Motivation	2.461	Very Large	Substantial increase in engagement, persistence, and autonomy.
Skill Performance	1.851	Large	Significant enhancement in motor execution and accuracy.

The PBL intervention produced substantial educational gains, particularly in learning motivation (d = 2.461), indicating that students became markedly more engaged, persistent, and autonomous compared to conventional instruction. Cognitive achievement showed a medium effect (d = 0.689), representing meaningful, practical improvement in conceptual understanding—approximately a 15% gain from baseline, directly impacting students' ability to recognize errors and apply safety principles. Skill performance also improved significantly (d = 1.851), reflecting enhanced motor control, accuracy, and execution of Pencak Silat kicking techniques.

In contrast, the control group demonstrated non-significant cognitive gains (p = 0.211), suggesting that conventional demonstration-practice methods primarily reinforce procedural fluency but do not sufficiently engage higher-order cognitive processes such as problem-solving, error detection, or tactical reasoning. These findings underscore the practical advantage of PBL in martial arts education: not only does it improve motivation and skill execution, but it also fosters deeper cognitive understanding and self-regulated learning.

Discussion

This study investigated the effectiveness of the Problem-Based Learning (PBL) model in enhancing cognitive achievement, learning motivation, and psychomotor skills among university students enrolled in Pencak Silat courses. The results demonstrated that PBL led to significant improvements across all measured outcomes compared to the control group. Post-test scores showed substantial differences in cognitive achievement ($M = +9.02$; $t = 3.416$; $p = 0.001$), learning motivation ($M = +0.77$; $t = 12.069$; $p < 0.001$), and psychomotor skills ($M = +2.54$; $t = 9.262$; $p < 0.001$). These findings were consistent with the within-group improvements observed in the experimental group, supporting the efficacy of PBL in integrating cognitive, motivational, and psychomotor learning.

The medium effect size for cognitive achievement ($d = 0.689$) suggests meaningful conceptual gains, although smaller than the very large motivational effect ($d = 2.461$). This indicates that while PBL effectively stimulates higher-order cognitive processing, its most pronounced impact lies in fostering engagement, persistence, and autonomy. Unlike traditional drill-based instruction, PBL requires learners to actively integrate technical skills with tactical reasoning, facilitating deeper understanding and problem-solving (Banihashem & Macfadyen, 2021; Liu & Pásztor, 2022). In practice, a 9-point gain out of a total possible score of 60–65 represents approximately 15% improvement, indicating moderate but educationally relevant advancement.

Learning motivation showed exceptionally large gains, consistent with Self-Determination Theory (Ryan & Deci, 2020), which highlights autonomy, competence, and relatedness as key drivers of intrinsic motivation. PBL fostered participatory decision-making, peer collaboration, and self-directed problem solving, reinforcing both engagement and self-efficacy. Previous studies in physical education and sports contexts corroborate these findings (Orhan, 2024; Wijnia, Noordzij, Arends, Rikers, & Loyens, 2024; Zakaria, Abdullah, Alhassora, Osman, & Ismail, 2025), indicating that PBL consistently enhances motivational outcomes, which in turn support skill development.

Psychomotor skill improvements ($d = 1.851$) demonstrate that cognitive and motivational gains translated into practical proficiency. Collaborative problem-solving, iterative testing of techniques, and immediate feedback—core features of PBL—align with motor learning theory (Schmidt & Lee, 2025) and facilitate skill refinement. Similar effects were reported in studies combining PBL with play-based or contextual learning (Visano, Gusril, Syahara, Putra, & Ockta, 2024). In Pencak Silat, these findings highlight that PBL promotes integrated learning, rather than isolated skill acquisition.

Comparison with control group outcomes revealed minimal cognitive improvement ($p = .211$), suggesting that traditional instruction, which emphasizes memorization and repetition, may insufficiently support conceptual understanding or tactical reasoning (Divayana et al., 2024). Conversely, PBL's scenario-based and reflective learning promoted meaningful application of knowledge, consistent with prior research in martial arts and sports pedagogy (Koçoğlu & Kanadlı, 2025; Lee & Jung, 2025).

Consideration of external factors: While improvements are attributable to PBL, novelty effects, Hawthorne effects, and increased instructor attention may also have contributed. Therefore, interpretations should be cautious, acknowledging that some gains might partially reflect enhanced learner engagement due to study conditions rather than solely the instructional model.

Educational Implications

1. Pedagogical Innovation: PBL provides a model for integrating tactical thinking, motivation, and technical execution in martial arts instruction.
2. Curriculum Development: PBL-informed frameworks can guide higher education curricula emphasizing inquiry, reflection, and collaboration.
3. Instructor Training: Teacher education programs should include constructivist pedagogy modules to equip instructors to facilitate PBL in physical and martial arts contexts.
4. Cultural Preservation: PBL implementation in traditional martial arts maintains cultural heritage while aligning with 21st-century educational paradigms.

Limitations

Despite the positive findings, this study has several limitations that affect the interpretation and generalizability of the results:

1. Sample and Setting: The research was limited to one university, which may not represent diverse student populations or instructional contexts in other institutions.
2. Intervention Duration: The eight-week PBL program may not fully capture long-term retention, transfer of learning, or sustainability of skill development.
3. Measurement Methods: Motivation and skill performance were assessed partly through self-report and instructor evaluation, which could introduce subjective bias.
4. Design Constraints: Using intact quasi-experimental groups cannot completely rule out alternative explanations, such as novelty effects or increased attention from instructors, rather than the PBL model alone.

Future research should replicate this study across multiple institutions, extend the intervention duration, and employ mixed-methods designs to examine sustained cognitive, motivational, and psychomotor outcomes, thereby providing more robust evidence of PBL's effectiveness in martial arts education.

Conclusions

The findings of this study indicate that the implementation of the Problem-Based Learning (PBL) model produced significant improvements in cognitive achievement, learning motivation, and technical skill performance among students participating in Pencak Silat courses. Specifically, the experimental group showed higher post-test scores in cognitive achievement (+9.02 points, $t = 3.416$, $p = 0.001$), learning motivation (+0.77 points, $t = 12.069$, $p < 0.001$), and skill performance (+2.54 points, $t = 9.262$, $p < 0.001$) compared to the control group.

However, these results should be interpreted cautiously. The study was conducted at a single university with a relatively short intervention period (eight weeks), which may limit the generalizability of the findings. While PBL demonstrated positive effects in this context, it is not guaranteed that the same magnitude of improvement would occur in other institutions, populations, or over longer-term implementations. Therefore, the results should be considered as indicative of potential benefits rather than universally applicable outcomes.

Theoretical Contribution

This research extends the application of Constructivism and Self-Determination Theory (SDT) to the domain of sports and martial arts education, illustrating how cognitive, motivational, and psychomotor constructs interact under an inquiry-based instructional framework. The study demonstrates that a well-designed PBL approach can effectively harmonize theory, motivation, and practice in culturally embedded disciplines, providing empirical evidence of its pedagogical utility in higher education martial arts programs.

Practical Contribution

For educators and curriculum designers, this study provides evidence that PBL can be successfully adapted to traditional disciplines such as Pencak Silat without compromising cultural authenticity. Educational institutions may implement this approach to enhance student engagement, optimize learning outcomes, and foster holistic development in physical and martial arts programs. Specifically, PBL offers a model for integrating tactical thinking, motivation, and technical execution, while guiding the design of curricula that emphasize inquiry, reflection, collaboration, and culturally grounded practice.

Limitations and Implications for Interpretation

Despite the positive findings, several limitations must be considered when interpreting the results:

1. Sample and Setting: The research was conducted at a single university with a relatively homogeneous student population, which limits generalizability. Findings may not fully represent outcomes in other institutions or diverse student populations.
2. Intervention Duration: The eight-week PBL program may not capture long-term retention, transfer of learning, or sustainability of skill development, suggesting caution in extrapolating the effectiveness of PBL over extended periods.
3. Measurement Methods: Motivation and skill performance were partly assessed through self-report and instructor evaluation, introducing potential subjectivity and bias.
4. Design Constraints: Using intact quasi-experimental groups cannot fully rule out alternative explanations such as novelty effects, increased instructor attention, or other external factors contributing to observed gains rather than the PBL model alone.

These limitations imply that while the observed improvements are statistically and practically meaningful, the results should be interpreted with care, and claims about the universal effectiveness of PBL should remain context-specific.

Future Research

Future studies should aim to replicate and extend these findings by:

- Conducting multi-institutional research to increase generalizability.
- Extending the duration of PBL interventions to examine long-term retention and skill sustainability.
- Incorporating mixed-methods designs to capture deeper insights into motivational dynamics, learning transfer, and psychomotor development.
- Integrating digital learning technologies to explore scalable and interactive PBL applications in martial arts education.

By addressing these areas, subsequent research can provide more robust evidence of PBL's effectiveness and practical applicability in diverse educational and cultural contexts.

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Conflict of interest

The authors declare no conflict of interest. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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