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Effects of Project-Based and Deep Learning Pedagogy on Dribbling Skills in Physical Education Students: A Quasi-Experimental Study

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Abstract: This study examined the effectiveness of integrating Project-Based Learning (PjBL) with a deep learning approach to improve university students' dribbling skills. A quantitative quasi-experimental method with a nonequivalent control group pretest–posttest design was employed. The participants were 70 students enrolled in the Physical Education Study Program at Universitas Lambung Mangkurat, consisting of 35 students in the experimental group and 35 in the control group. The experimental group received PjBL integrated with mindful, meaningful, reflective, collaborative, and joyful learning principles, whereas the control group received conventional instruction. Dribbling performance was assessed using an instrument adapted from the Modified Illinois Change-of-Direction Test with Ball, measuring change-of-direction speed, ball control, foot–ball contact, visual attention, and the ability to avoid contact with cones. The experimental group's mean score increased from 69.09 at pretest to 79.69 at posttest, while the control group's mean score increased from 69.09 to 71.31. Analysis of covariance, with posttest score as the dependent variable and pretest score as the covariate, revealed a significant group effect after controlling for initial ability, $F(1, 67) = 287.29$, $p < 0.001$, partial $\eta^2 = 0.811$. The adjusted posttest mean was significantly higher in the experimental group ($M = 79.69$, $SE = 0.35$) than in the control group ($M = 71.31$, $SE = 0.35$), with an adjusted mean difference of 8.37 points, 95% CI [7.39, 9.36]. These findings indicate that integrating PjBL with a deep learning approach produced a substantial improvement in university students' dribbling skills.

Keywords: Project-Based Learning, Deep Learning, Dribbling Skills, Football, Physical Education, Quasi-Experimental Study.

1. Introduction

Football requires players to integrate physical, technical, tactical, perceptual, and decision-making abilities. One of the technical skills that plays a central role in football performance is dribbling. Dribbling refers to the ability to carry and control the ball with the feet while moving, changing direction, overcoming opponents, maintaining possession, and creating space for passing or shooting. Effective dribbling is determined not only by running speed but also by the quality and frequency of ball touches, eye–foot coordination, dynamic balance, bilateral foot use, change-of-direction ability, and decision-making accuracy (Leal *et al.,* 2022; Mao *et al.,* 2024; Pacheco *et al.,* 2023). Dribbling should therefore be understood not merely as an isolated technical movement but as a perceptual–motor and technical–tactical action performed in response to spatial constraints, time pressure, opponent positioning, and the objectives of play. In university-level football instruction, dribbling is commonly taught through lecturer explanations, demonstrations, standardized technical drills, repeated practice, and end-of-session evaluation. Repetition remains important for motor-skill acquisition because it enables learners to stabilize movement patterns and improve movement efficiency. However, repetitive instruction that positions students primarily as recipients of information may provide limited opportunities to analyze movement quality, identify performance problems, design appropriate practice tasks, use feedback, and independently regulate skill development. Such limitations are particularly relevant for students in Physical Education Study Programs, who are expected not only to demonstrate sports skills but also to understand instructional principles, design training activities, evaluate performance, and explain the rationale for selecting particular training methods.

Dribbling instruction therefore needs to move beyond lecturer-centered technical practice toward a learning process that gives students greater responsibility for planning, implementing, monitoring, and evaluating their own learning. One instructional model that may support these responsibilities is Project-Based Learning, or PjBL. PjBL organizes learning around authentic questions or problems that require planning, investigation, collaboration, product development, presentation, and reflection. In this model, the project is not an additional assignment completed after the content has been taught; rather, it constitutes the central structure through which learning occurs (Guo *et al.,* 2020; Haatainen & Aksela, 2021). Studies in higher education have demonstrated that PjBL can improve knowledge, practical skills, learning engagement, collaboration, problem-solving, self-regulation, and the quality of student products (Almulla, 2020; Guo *et al.,* 2020). Its principal characteristics include driving questions, authentic problems, student autonomy, investigation, collaboration, product development, presentation, and reflection (Haatainen & Aksela, 2021; Markula & Aksela, 2022). A recent meta-analysis also demonstrated that PjBL positively affects learning outcomes compared with traditional instruction, although its effectiveness may vary according to the field of study, duration of implementation, group size, project design, and quality of lecturer facilitation (Zhang & Ma, 2023).

In physical education, projects may include training-program design, movement analysis, video documentation, performance-progress measurement, development of practice courses, solution of movement-related problems, and presentation of training outcomes. Through these activities, students are required to connect theoretical knowledge with practical experience by designing, implementing, observing, and evaluating physical activities that constitute the products of their projects (Simonton *et al.,* 2021; Zavala-Crichton *et al.,* 2023). Nevertheless, the use of a project does not automatically produce deep understanding or high-quality psychomotor learning. When projects are insufficiently scaffolded, students may focus primarily on completing a product, dividing tasks among group members, or fulfilling assessment requirements without adequately analyzing their movements, using feedback, or regulating their practice. Consequently, PjBL requires explicit pedagogical mechanisms that direct students' attention toward the quality of both the learning process and the resulting performance.

The effectiveness of PjBL may therefore be strengthened by integrating it with a deep learning approach. In this study, deep learning does not refer to artificial intelligence or machine learning but to a pedagogical approach that promotes in-depth understanding, meaning-making, critical thinking, reflection, metacognition, and the transfer of learning to new situations (Gatz & Akiva, 2024; Mthethwa-Kunene *et al.,* 2022; Mystakidis, 2021; Mystakidis *et al.,* 2021). Deep learning cannot be achieved merely by increasing the amount of content or frequency of practice. Students need to understand the purpose of each activity, connect new knowledge with previous experience, monitor their learning process, evaluate the quality of their performance, use feedback, correct errors, and apply their understanding in authentic situations. A deep learning environment therefore requires relevant, challenging, interactive, and collaborative tasks that provide learners with opportunities to make decisions and take responsibility for their learning (Mthethwa-Kunene *et al.,* 2022; Mystakidis, 2021).

PjBL and deep learning are combined because they serve complementary instructional functions. PjBL provides the structural conditions for learning through an authentic project, learner autonomy, collaboration, investigation, product development, and presentation. Deep learning provides the cognitive, metacognitive, motivational, and reflective mechanisms through which students derive meaningful learning from those project activities. Thus, PjBL structures the project activities and outputs, while deep-learning principles guide students' attention, interpretation, reflection, monitoring, and performance improvement throughout the project.

Within the Indonesian educational context, deep learning can be operationalized through mindful, meaningful, and joyful learning (Fitrah *et al.,* 2025), together with reflective and collaborative learning processes. Each principle may support motor-skill acquisition through a distinct cognitive, motivational, reflective, or self-regulatory mechanism. First, mindful learning directs students' attention toward learning objectives, movement cues, initial performance limitations, and progress indicators. In dribbling practice, mindful attention may help students recognize ineffective ball touches, inappropriate body position, loss of balance, or inefficient changes of direction. It also supports goal setting and performance monitoring, which are central components of self-regulated learning.

Second, meaningful learning connects technical movements with authentic football situations. Instead of practicing dribbling as an isolated sequence, students examine why a particular touch, direction change, or speed adjustment is required in response to an opponent, available space, or tactical objective. This connection helps students develop functional movement understanding and facilitates the transfer of practice outcomes to game-related situations.

Third, reflective learning enables students to compare intended and actual performance, interpret video recordings and test results, identify errors, and revise subsequent practice. Structured reflection helps students convert feedback into specific corrective actions. It therefore supports the cyclical processes of planning, performance monitoring, self-evaluation, and adaptation that characterize self-regulated learning.

Fourth, collaborative learning provides opportunities for peer observation, demonstration, verbal explanation, feedback, and co-regulation. By observing and evaluating one another's movements, students may identify technical details that are difficult to recognize during their own performance. Explaining movement problems and possible solutions may also strengthen students' conceptual understanding of dribbling mechanics and training design.

Fifth, joyful learning supports motivation, persistence, experimentation, and willingness to repeat demanding movement tasks. Joyful learning can maintain instructional rigor while promoting motivation, persistence, experimentation, and willingness to practise. Rather, it creates a psychologically safe and appropriately challenging environment in which students can make errors, receive feedback, revise their performance, and experience gradual success. These conditions are important because motor-skill improvement requires sustained engagement and repeated attempts.

Accordingly, the integration of PjBL and deep learning is expected to produce stronger psychomotor learning than PjBL implemented without explicit deep-learning scaffolds. A project alone may lead to task completion, whereas an integrated approach requires students to consciously set performance goals, connect practice with authentic playing situations, analyze their own movements, respond to peer and lecturer feedback, revise practice designs, and evaluate improvement. These processes promote more deliberate, varied, and feedback-informed practice, promote error detection and correction, strengthen perception–action connections, and support self-regulated skill development. However, because the present study compared the integrated intervention with conventional instruction rather than with a PjBL-only condition, its design evaluates the effectiveness of the integrated approach but does not directly isolate the additional effect of deep-learning principles over PjBL alone.

The five deep-learning principles are proposed to influence dribbling performance indirectly by strengthening self-regulated learning. Mindful learning supports attention and goal setting; meaningful learning connects movement practice with authentic football demands; reflective learning converts feedback into corrective action; collaborative learning enables peer observation and co-regulation; and joyful learning sustains motivation and persistence. Together, these processes are expected to improve the quality of deliberate and variable practice, thereby supporting error detection, technical correction, perception-action coupling, and psychomotor skill acquisition.

In the present intervention, students designed and implemented a dribbling-training project. Rather than merely performing exercises prescribed by the lecturer, they identified weaknesses in their initial performance, formulated improvement goals, developed variations of dribbling courses, established performance indicators, implemented practice activities, recorded their movements, analyzed the results, provided peer feedback, revised the training design, and presented the final project. The project combined repeated dribbling practice with knowledge construction, movement analysis, peer feedback, collaboration, decision-making, reflection, and self-monitoring.

Research on PjBL in higher education has predominantly examined students' perceptions, engagement, thinking skills, knowledge, creativity, and academic products. Learning outcomes involving behavioral skills and objectively measured motor performance have received comparatively less attention than cognitive and affective outcomes (Guo *et al.,* 2020). PjBL studies in physical education have also tended to focus on student experiences, physical activity, instructional-design competence, and the development of prospective teachers (Simonton *et al.,* 2021; Zavala-Crichton *et al.,* 2023). Meanwhile, football-instruction studies have generally focused on technical training, tactical approaches, small-sided games, and physical factors associated with dribbling performance (Leal *et al.,* 2022; Mao *et al.,* 2024). Studies that systematically integrate PjBL syntax with mindful, meaningful, reflective, collaborative, and joyful learning principles to improve objectively measured dribbling skills among university students remain limited.

The novelty of this study lies in the systematic integration of PjBL with a deep learning approach in university-level football instruction. Unlike previous studies that have predominantly focused on cognitive, affective, or general learning outcomes, the present study places psychomotor dribbling performance as its primary outcome and evaluates it through a performance-based test. The intervention uses an authentic project involving the design, implementation, documentation, analysis, evaluation, and revision of dribbling exercises. Deep-learning principles are explicitly incorporated into each stage of the project to strengthen attention, meaning-making, reflection, collaboration, motivation, and self-regulated learning. The study also compares pretest and posttest performance, improvement scores, effect sizes, and adjusted final scores after controlling for initial ability. The study provides context-specific empirical evidence from a university physical education program at Universitas Lambung Mangkurat.

Based on the identified research gap, this study aimed to determine the effect of integrating PjBL with a deep learning approach on university students' dribbling skills and to examine the effectiveness of this integrated intervention compared with conventional instruction. It was hypothesized that students who participated in the integrated PjBL and deep learning intervention would demonstrate significantly greater improvements in dribbling performance than students who received conventional instruction

2. Materials and Methods

2.1 Research Approach and Design

This study employed a quantitative approach using a quasi-experimental method. A quasi-experimental method was selected because the researchers administered an intervention to specific groups, although the participants were not assigned through full individual randomization. Group allocation was based on existing classes or course groups.The study used a nonequivalent control group pretest–posttest design. This design involved an experimental group and a control group, both of which completed a pretest and a posttest. The pretest was administered to determine the participants' initial ability before the intervention, whereas the posttest was administered to identify changes following the intervention. A nonequivalent control group design is commonly used when full randomization is not feasible. Nevertheless, researchers must examine the equivalence of the groups' initial abilities and statistically control for potential baseline differences (Bulus, 2021). The research design is illustrated in Figure 1.

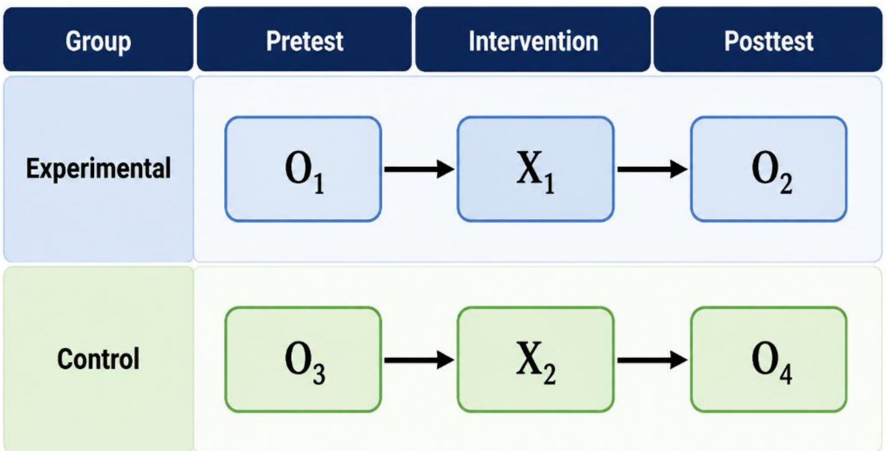

Figure 1. Research design.

O_1: pretest of the experimental group;

O_2: posttest of the experimental group;

O_3: pretest of the control group;

O_4: posttest of the control group;

X_1: integration of PjBL with a deep learning approach; and

X_2: conventional instruction.

The independent variable was the integration of the PjBL model with a deep learning approach, whereas the dependent variable was the students' dribbling skills.

2.2 Population and Sample

The study population consisted of students enrolled in the Physical Education Study Program at Universitas Lambung Mangkurat who were taking a football course. The sample comprised 70 students: 35 in the experimental group and 35 in the control group. Participants were allocated according to pre-existing course classes rather than by individual random assignment. This intact-class allocation was necessary for operational reasons but may have introduced selection bias because unmeasured differences between classes could not be eliminated. Baseline dribbling scores were therefore compared, and pretest performance was included as a covariate in ANCOVA.

The experimental group received instruction through the integration of the PjBL model with a deep learning approach, whereas the control group received conventional dribbling instruction. Both groups were provided with equivalent learning content, facilities, practice opportunities, instructional time, and measurement procedures. The primary difference between the groups was the instructional model and the learning activities implemented.

Because the intervention was delivered at the class level and involved visibly different learning activities, blinding of participants and the lecturer was not feasible. To reduce detection bias, outcome assessment should be performed by assessors who are unaware of group allocation whenever practicable, and scoring should follow a standardized rubric.

2.3 Experimental Group Treatment Procedures

The intervention was conducted over one instructional unit focusing on dribbling skills and consisted of eight sessions, each lasting 90 minutes. The Project-Based Learning (PjBL) model was integrated with a deep learning approach throughout the intervention. At the project-planning stage, students were divided into small groups and asked to develop a dribbling-skill training project. Each project included clearly defined objectives, technical problems to be addressed, variations of training activities, the design and distance of the training course, training intensity, the number of repetitions, the use of dominant and non-dominant feet, indicators of success, the distribution of responsibilities, an implementation schedule, and a plan for project documentation.

After developing the project plan, students organized the stages of project implementation and assigned specific roles to group members. These roles included training participants, technical observers, timekeepers, error recorders, video recorders, feedback providers, and project report writers. Assigning roles was intended to encourage individual accountability, active participation, and collaboration among group members (Alamri, 2021; Hussein, 2021). The structure, learning activities, lecturer roles, deep-learning principles, duration, and fidelity checks for the eight-session intervention are summarized in Table 1. During project implementation, students carried out the training programs they had designed. The activities consisted of straight-line dribbling, slalom dribbling, changing direction using the inside and outside of the foot, using both dominant and non-dominant feet, dribbling with variations in speed, dribbling under time pressure, dribbling based on directional decision-making, and simulations of dribbling past an opponent. Throughout the activities, the lecturer served as a facilitator who monitored participant safety, the appropriateness of the training load, the involvement of group members, and the accuracy of the techniques performed.

2.4 Research Instrument

Dribbling performance was assessed using an instrument adapted from the Modified Illinois Change-of-Direction Test with Ball (ICODT-BALL) described by Makhlouf *et al.* (2022). The test was selected because it integrates rapid directional changes with ball control and therefore reflects important perceptual-motor and technical components of dribbling. Administration should be standardized with respect to course dimensions, cone placement, starting position, verbal instructions, number of trials, rest interval, footwear, surface, timing method, and error criteria.

Table 1. Eight-Session Intervention Schedule

Session	Main Focus	Learning and Project Activities	Lecturer Role and Assessment	Deep Learning Principles	Duration	Project Output / Fidelity Check
1	Orientation and initial diagnosis	Introduction to the project, initial dribbling test, video recording, identification of strengths and weaknesses, and reflection.	Explain procedures, ensure safety, and assess initial performance using a checklist and video.	Mindful, meaningful, and reflective learning	90 min	Baseline record, video file, diagnostic reflection; attendance and checklist
2	Movement analysis and project planning	Analyze dribbling movements, set improvement targets, and develop a group training plan.	Guide movement analysis and assess the feasibility of the project plan.	Mindful, meaningful, and collaborative learning	90 min	Approved group plan and targets; lecturer feasibility checklist
3	Ball control and use of both feet	Design and perform drills focusing on ball touches, body position, and bilateral-foot control.	Demonstrate techniques, monitor practice, and provide feedback.	Mindful, collaborative, and joyful learning	90 min	Technique-practice log and peer feedback sheet; lecturer observation
4	Direction changes and balance	Design and perform dribbling courses involving turns, cuts, and different movement patterns.	Adjust task difficulty and assess performance through observation and video.	Meaningful, mindful, and reflective learning	90 min	Designed course and video evidence; task-difficulty record
5	Speed, space, and time constraints	Modify drills by adding time limits, restricted spaces, and decision-making tasks.	Manage task constraints and evaluate speed, control, and movement errors.	Meaningful, joyful, and reflective learning	90 min	Constraint-based drill record and performance log; error checklist
6	Progress evaluation and project revision	Compare current and initial performance, analyze progress, and revise the training program.	Assist data interpretation and provide formative feedback.	Reflective, mindful, and collaborative learning	90 min	Progress comparison and revised plan; formative-feedback record
7	Authentic application and final product	Apply dribbling skills in game-related situations and complete the training-product documentation.	Ensure authentic and safe activities and assess the final project development.	Meaningful, collaborative, and joyful learning	90 min	Completed project documentation; final-product rubric
8	Final test, presentation, and reflection	Complete the posttest, present the project results, receive feedback, and conduct final reflection.	Administer the final assessment and evaluate performance, presentation, and project outcomes.	Reflective, mindful, collaborative, and joyful learning	90 min	Posttest record, presentation, and final reflection; assessment rubric

Daniel et al. (2020) also showed that change-of-direction tests involving a ball can be used to evaluate dribbling ability when the course design, instructions, timing procedures, and error criteria are standardized. Furthermore, Rodriguez-Giustiniani *et al.* (2022) emphasized the importance of reliable football-skill measurements when such tests are used to evaluate changes in performance. More recent assessments have conceptualized dribbling as a motor-cognitive task that integrates ball control, navigation, speed, and decision-making (Klotzbier & Schott, 2024).

This instrument was selected because dribbling involves more than running while controlling the ball. It assesses several integrated components of dribbling performance, including ball control, appropriate touch distance, eye–foot coordination, change-of-direction ability, movement speed, and dynamic balance. The assessment also considers the use of both the dominant and non-dominant feet, the ability to keep the ball close to the body while moving, and the efficiency with which participants complete the designated course. The correlation between the two repeated instrument administrations is reported in Table 2.

The correlation between Test 1 and Test 2 was very strong and statistically significant, $r = .993$, $p < .001$. This result demonstrates a strong association between the repeated measurements. Because correlation alone does not establish measurement agreement or construct validity, the finding is interpreted as supporting consistency between trials rather than as definitive evidence of validity. Current-sample repeated-measurement results are presented in Table 3.

In the current sample, repeated measurements were strongly correlated (Pearson's $r = 0.978$, $p < 0.001$; $n = 35$). Although this result indicates a strong linear association between test occasions, correlation alone does not quantify absolute agreement. Reliability should therefore also be reported using an intraclass correlation coefficient with a 95% confidence interval and an absolute-error index such as the standard error of measurement. The weighting of the four dribbling-skill assessment components is shown in Table 4.

The total score was intended to range from 0 to 100 points, comprising completion time (maximum 50 points), foot-ball contact technique (30 points), visual attention (10 points), and ball control without cone contact (10 points). For reproducibility, the manuscript must specify the raw-time conversion rule and the observable scoring anchors for every qualitative component.

Table 2. Repeated-Measurement Correlation for the Instrument

Measurement comparison	Pearson's r	Critical r	p value	Interpretation
Test 1 and Test 2	0.993	0.632	< 0.001	Very strong positive correlation

Table 3. Current-Sample Test-Retest Results

N	Test 1, M (SD)	Test 2, M (SD)	Pearson's r	p value	Interpretation
35	70.11 (4.70)	70.66 (5.07)	0.978	< 0.001	Very strong test–retest correlation

Table 4. Dribbling Skill Assessment Rubric

No.	Assessment Component	Maximum Score	Weight (%)
1	Completion time	50	50%
2	Football contact technique	30	30%
3	Visual attention while dribbling	10	10%
4	Ball control without touching the cones	10	10%
Total		100	100%

2.5 Data Analysis

Data were summarized using means, standard deviations, medians, and ranges. The Shapiro-Wilk test was used to assess normality, and Levene's test was used to examine homogeneity of variance. Because several score distributions did not satisfy the normality assumption, within-group pretest-posttest changes were examined using the Wilcoxon signed-rank test, and between-group comparisons of pretest, posttest, and change scores were examined using the Mann-Whitney U test. An analysis of covariance (ANCOVA) was additionally conducted with posttest score as the dependent variable, group as the fixed factor, and pretest score as the covariate. The homogeneity-of-regression-slopes assumption and equality of error variances were tested before interpreting ANCOVA. Statistical significance was set at $p < 0.05$. For ANCOVA, partial eta squared was reported as the effect-size measure, and adjusted mean differences were reported with 95% confidence intervals.

3. Results

3.1 Description of Score Improvements

All 35 students in the experimental group demonstrated improved scores. Twenty-eight students improved by 10 points, while the remaining seven students improved by between 11 and 15 points. In the control group, 17 students demonstrated improved scores, whereas 18 students showed no change. The median improvement in the control group was 0.00, indicating that at least half of the students in the control group did not improve their scores. Descriptive statistics for score improvements in both groups are presented in Table 5.

3.2 Levene's Test of Homogeneity of Variance

Levene's test was conducted to determine whether the variances of the experimental and control groups were homogeneous. The results showed that the pretest variances were homogeneous, with $p = 1.000$, and the posttest variances were also homogeneous, with $p = 0.922$. However, the variances of the improvement scores were not homogeneous, with $p = 0.001$. Although the improvement-score variances were not homogeneous, the Mann-Whitney U test remained appropriate because it is a nonparametric test and does not require the assumption of normally distributed data.

3.3 Wilcoxon Signed-Rank Test

The Wilcoxon signed-rank test was used to compare the pretest and posttest scores within each group. In the experimental group, the test yielded $W = 0.00$, $p < .001$. The mean score increased from 69.09 on the pretest to 79.69 on the posttest, representing an average improvement of 10.60 points. These results indicate a statistically significant improvement in students' dribbling skills after participating in the integration of Project-Based Learning with a deep learning approach.

In the control group, the Wilcoxon signed-rank test also yielded $W = 0.00$, $p < .001$. The mean score increased from 69.09 on the pretest to 71.31 on the posttest, representing an average improvement of 2.23 points. Thus, the control group also demonstrated a statistically significant improvement. However, the magnitude of the improvement was descriptively smaller than that observed in the experimental group.

3.4 Mann-Whitney U Test

The Mann-Whitney U test was used to compare the pretest scores, posttest scores, and improvement scores between the experimental and control groups. The pretest comparison yielded $U = 609.00$, $p = .970$. Because the p-value was greater than 0.05, there was no statistically significant difference in initial dribbling skills between the experimental and control groups. Both groups had the same mean pretest score of 69.09, suggesting similar measured baseline dribbling performance; however, equivalence on unmeasured characteristics cannot be assumed.

Table 5. Descriptive Statistics for Score Improvements

Group	Mean improvement	SD	Median	Range
Experimental	10.60	1.42	10.00	10-15
Control	2.23	2.53	0.00	0-10

The posttest comparison yielded U = 1089.00, $p < .001$. Posttest scores were significantly higher in the experimental group than in the control group. The improvement-score comparison yielded U = 1211.00, $p < .001$. Therefore, the improvement in dribbling skills among students in the experimental group was significantly greater than the improvement observed in the control group.

3.5 Summary of Hypothesis Testing

The principal hypothesis-testing results are summarized in Table 6. Taken together, the statistical findings supported the study hypothesis. Students who received the integrated PjBL and deep-learning intervention demonstrated significantly greater improvements in dribbling performance than students who received conventional instruction.

The ANCOVA group effect was very large (partial $\eta^2 = 0.811$), and the adjusted between-group mean difference was 8.37 points (95% CI [7.39, 9.36]). These model-based estimates provide the principal effect-size and precision measures for the adjusted posttest comparison. The ANCOVA results for posttest dribbling scores are reported in Table 7.

Adjusted posttest means and the adjusted between-group difference are presented in Table 8. An analysis of covariance was conducted to examine the effect of integrating Project-Based Learning with a deep learning approach on students' dribbling skills, with posttest score as the dependent variable and pretest score as the covariate. The homogeneity-of-regression-slopes assumption was satisfied, as the interaction between group and pretest score was not significant, $F(1, 66) = 0.012$, $p = 0.913$. Levene's test also indicated equal error variances, $F(1, 68) = 0.010$, $p = 0.921$. After controlling for pretest scores, a statistically significant difference was found between the experimental and control groups, $F(1, 67) = 287.29$, $p < 0.001$, partial $\eta^2 = 0.811$. The adjusted posttest mean was higher in the experimental group (M = 79.69, SE = 0.35) than in the control group (M = 71.31, SE = 0.35), with an adjusted mean difference of 8.37 points, 95% CI [7.39, 9.36].

Table 6. Summary of the Statistical Analysis

Analysis	Statistical value	p-value	Conclusion
Pretest comparison	U = 609.00	0.970	No significant difference
Experimental-group pretest–posttest comparison	W = 0.00	<0.001	Significant improvement
Control-group pretest–posttest comparison	W = 0.00	<0.001	Significant improvement
Posttest comparison	U = 1089.00	<0.001	Significant difference
Improvement-score comparison	U = 1211.00	<0.001	Significant difference

Table 7. ANCOVA Results for Posttest Dribbling Score

Source	Sum of Squares	df	Mean Square	F	p	Partial η^2
Pretest score	1,299.072	1	1,299.072	304.314	< 0.001	0.820
Group	1,226.414	1	1,226.414	287.294	< 0.001	0.811
Error	286.013	67	4.269	-	-	-
Corrected total	2,811.500	69	-	-	-	-

Table 8. Adjusted Posttest Means

Group	Adjusted Mean	Standard Error	95% Confidence Interval
Experimental	79.69	0.35	78.99–80.38
Control	71.31	0.35	70.62–72.01
Adjusted mean difference	8.37	0.49	7.39–9.36

These results indicate that the integration of Project-Based Learning with a deep learning approach had a substantial positive effect on students' dribbling skills.

4. Discussion

The present study found that students who participated in Project-Based Learning (PjBL) integrated with a deep learning approach demonstrated substantially greater improvement in football dribbling skills than students who received conventional instruction. The experimental group's mean score increased from 69.09 at the pretest to 79.69 at the posttest, representing a gain of 10.60 points or approximately 15.34% of the initial score. In comparison, the control group increased from 69.09 to 71.31, equivalent to a gain of 2.22 points or approximately 3.21%. After controlling for pretest scores, the adjusted mean difference between the groups was 8.37 points, with a 95% confidence interval ranging from 7.39 to 9.36. The group effect was statistically significant, $F(1, 67) = 287.29$, $p < .001$, with a partial eta squared of .811. Thus, within the conditions of this study, the integrated intervention produced a substantially greater immediate improvement in dribbling performance than conventional instruction.

The size of the observed improvement can be compared with effects reported in previous football skill-acquisition studies. A systematic review and meta-analysis of small-sided-game interventions reported a moderate between-group effect on technical execution, with an overall effect size of approximately 0.59. Interventions lasting more than 17 sessions produced an effect size of approximately 0.68, whereas shorter interventions produced an effect of approximately 0.44 (Clemente *et al.,* 2021). Similarly, a meta-analysis examining the effects of physical education on motor competence reported a moderate overall effect of approximately 0.69 (Lorås, 2020). Feedback-based interventions in physical education have also generally produced more modest effects, with a meta-analytic standardized mean difference of approximately 0.47 for motor-skill learning (Han *et al.,* 2022). These findings indicate that improvements in motor and sport skills are commonly small to moderate rather than exceptionally large.

Evidence from football-specific interventions also indicates that additional training does not always produce substantially greater gains than regular practice. For example, a randomized study of a 10-week technology-supported football training program found improvements over time but did not identify a significant additional group-by-time benefit for several sport-specific motor outcomes, including agility with the ball (Szabó *et al.,* 2024). Therefore, although specialized football practice can improve performance, its superiority over standard training may depend on the instructional content, training intensity, learner characteristics, and outcome measures used.

The current findings can also be compared with previous studies of PjBL in physical education. A football-specific study reported that implementing PjBL contributed positively to students' dribbling skills development (Hardinata *et al.,* 2023). This finding is consistent with the present study, despite differences in participant characteristics, learning duration, assessment procedures, and research design should be considered when comparing the magnitude of improvement. This finding is consistent with the study conducted by Hadiana et al. (2022), who reported that the implementation of Project-Based Learning (PjBL) had a positive effect on football learning outcomes, particularly in the psychomotor domain involving passing and stopping skills. Their study involved 60 junior high school students and employed a true experimental design with a randomized posttest-only control group. Although these findings support the effectiveness of PjBL in developing football-related motor skills, differences in the specific skills assessed, participant characteristics, instructional duration, assessment procedures, and research design should be considered when comparing the magnitude of improvement with the present study.

Other research comparing PjBL with problem-based learning in football instruction found that both approaches improved passing performance but did not demonstrate a statistically significant difference between the two instructional models (Mukti & Priambodo, 2021). Together, these studies suggest that student-centred and project-based approaches may improve physical education outcomes. However, they also indicate that PjBL is not automatically superior under all instructional conditions and that its effectiveness may depend on how the model is designed and implemented.

At a broader educational level, a meta-analysis of PjBL studies reported an average effect of approximately 0.71 on academic achievement (Chen & Yang, 2019). This represents a meaningful effect but is still considerably smaller than the partial eta squared of .811 found in the present study. However, the two statistics should not be treated as directly equivalent. Cohen's d and related standardized mean differences express differences in standard-deviation units, whereas partial eta squared represents the proportion of outcome variance associated with an effect after accounting for other variables in a particular statistical model. Partial eta squared can therefore appear numerically larger, especially in a controlled, short-duration study using an outcome closely aligned with the intervention.

The unusually large effect may reflect both instructional and methodological factors. First, the outcome measure closely matched the skills practised during the intervention. Students repeatedly practised the same domain of football dribbling that was subsequently assessed during the posttest. Educational interventions generally produce larger effects on outcomes that are directly aligned with instructional activities than on broader, distal, or transfer outcomes. The intervention was therefore likely to influence the specific dribbling test more strongly than it would influence general football competence, tactical decision-making, or performance during competitive matches.

Second, the treatment provided a relatively intensive learning experience consisting of eight sessions of 90 minutes each. During these sessions, students were exposed to authentic projects, structured repetition, collaborative problem-solving, performance analysis, peer and instructor feedback, and reflective activities. Rather than merely repeating a prescribed movement, students were required to identify performance problems, plan practice activities, observe and analyse execution, evaluate progress, and revise their movement strategies. The combination of physical repetition and cognitive engagement may have strengthened the perception–action relationship and helped students develop greater awareness of ball control, movement direction, speed, body position, and errors in technique.

Third, PjBL and the deep learning approach may have operated synergistically. PjBL provided an authentic project structure, shared responsibility, a tangible performance product, and opportunities for collaboration. The deep learning approach added mindful participation, meaningful connections between concepts and practice, reflection on performance, and active revision of learning strategies. These components may have increased students' ownership of practice and encouraged them to process movement-related information more deeply than students in conventional instruction. The observed improvement may therefore reflect the combined effects of the two instructional components rather than the independent effect of either PjBL or deep learning.

Fourth, the novelty of the learning environment and the greater attention received by the experimental group may have increased motivation, persistence, and engagement. Students who knew that they were participating in an innovative instructional program may have devoted greater effort to practice and posttest performance. This potential Hawthorne effect is particularly relevant because the control group did not receive an intervention matched for novelty, collaborative activity, instructor attention, or perceived innovation.

Finally, methodological characteristics may have contributed to the large effect estimate. The study involved a relatively small, non-randomized sample from one university and one football course. The same instructional context, instructor, testing procedure, and institutional environment may have reduced variability within the experimental group and increased the apparent consistency of the treatment effect. Instructor enthusiasm, expectations, instructional competence, and fidelity to the intervention may also have favoured the experimental condition.

Furthermore, immediate posttesting may have captured short-term performance gains and familiarity with the assessment rather than stable learning retained over time. Educational effect sizes are influenced by research design, sample size, outcome proximity, implementation quality, and study context.

Consequently, unusually large effects obtained in relatively small and highly controlled studies should not be assumed to occur at the same magnitude when an intervention is implemented across multiple institutions, instructors, or student populations (Kraft, 2020).

Overall, the findings provide promising preliminary evidence that integrating PjBL with a deep learning approach can support immediate improvement in university students' football dribbling performance. Nevertheless, the very large effect should be interpreted as specific to the participants, instructional setting, outcome measure, and study design used. It should not be interpreted as evidence that the approach will generate an equally large effect across all football courses, universities, student populations, or physical education contexts.

4.1 Limitations and Future Research

This study has several limitations that should be acknowledged. First, participants were not randomly assigned to the experimental and control groups. Although the groups had comparable pretest means and ANCOVA was used to adjust for initial performance, selection bias and unmeasured group differences cannot be completely excluded. Second, the relatively small sample was drawn from one university and one football course, limiting the statistical precision and external validity of the findings.

Third, dribbling performance was measured immediately after the intervention. The study therefore cannot determine whether the improvement represented stable motor learning or a temporary performance effect. Delayed retention and transfer tests are needed to establish whether the skills are maintained over time and applied in authentic game situations.

Fourth, PjBL and deep learning were implemented as one integrated instructional package. Consequently, the independent contribution of each component and the possibility of an interaction between them could not be isolated. It is therefore not possible to determine whether the observed improvement was primarily produced by PjBL, the deep learning approach, or the interaction between the two components.

Fifth, the intervention may have been influenced by instructor-related factors, including instructional expertise, enthusiasm, expectations, feedback quality, and greater attention to the experimental group. Sixth, the novelty and increased engagement associated with the intervention may have produced a Hawthorne effect. Greater motivation or awareness of participating in an experimental program may have contributed to the observed improvement.

Finally, repeated exposure to similar dribbling activities may have increased familiarity with the posttest. Future multicentre studies should employ larger samples, randomized or cluster-randomized allocation, multiple instructors, systematic fidelity assessment, attention-matched control conditions, and delayed retention and transfer tests.

Factorial designs comparing PjBL alone, deep learning alone, their integrated implementation, and conventional instruction would also help identify the specific contribution of each instructional component.

5. Conclusion

This study suggests that integrating Project-Based Learning with a deep learning approach can improve football dribbling performance among students enrolled in the Physical Education Study Program at Universitas Lambung Mangkurat. Across eight instructional sessions, the experimental group increased its mean dribbling score from 69.09 at the pretest to 79.69 at the posttest, whereas the control group increased from 69.09 to 71.31. After adjustment for pretest scores, the experimental group retained an estimated advantage of 8.37 points. The statistically significant group effect and very large partial eta squared indicate that, within this particular course and research setting, the integrated intervention was more effective than conventional instruction in producing immediate improvement in the assessed dribbling skill.

The practical implication is that university football instructors may consider organizing technical learning through authentic projects involving clearly defined performance goals, structured and repeated practice, peer collaboration, observation, feedback, performance analysis, and guided reflection. These activities may help students move beyond mechanical repetition by encouraging them to identify errors, test possible solutions, monitor their progress, and revise their techniques. However, the results should be applied cautiously. The study involved a relatively small, non-randomized sample from one university. The intervention was implemented by one instructor in a single football course, and performance was assessed immediately after the intervention. Moreover, PjBL and deep learning were evaluated as an integrated package, meaning that the individual contribution of each component could not be determined.

Consequently, the findings do not establish that the approach is universally effective across higher education institutions, all football courses, or all physical education contexts. Broader educational recommendations should only be made after further multicentre research involving larger and more diverse samples, randomized or cluster-randomized designs, multiple instructors, and systematic monitoring of implementation fidelity.

Future studies should also include delayed retention and transfer assessments and compare PjBL alone, deep learning alone, and their integrated implementation to determine whether the gains are sustained and transferred to decision-making and dribbling performance in authentic game situations.

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Author Contribution Statement

Ramadhan Arifin: Conceptualization, Methodology, Validation, Formal analysis, Writing – original draft. Widiastuti: Formal analysis, Writing – original draft. Nofi Marlina Siregar: Validation. Lazuardy Akbar Fauzan: Writing – review & editing. Akhmad Amirudin: Writing –

review & editing. All the authors read and approved the final version of this manuscript.

Ethics Approval

Ethical approval for this study was obtained from the Institutional Review Board.

Participant Consent

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Yes