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Equipment Modification for Motor Skill Acquisition in Primary Physical Education: A Classroom Action Research Study of Rubber-Ball Volleyball Underhand Passing

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ABSTRACT

Background & objective: Volleyball underhand passing is a fundamental skill in primary PE, yet standard volleyball equipment may be difficult for novice children to control. This study examined whether integrating low-cost rubber-ball media into classroom instruction could improve Grade 4 students' underhand-passing performance and achievement of a mastery criterion.

Materials & Methods: A prospective classroom action research design was implemented in one intact Grade 4 class at a state elementary school in Tebing Tinggi, Indonesia. Thirty-four students ($n = 34$) completed pre-cycle, Cycle I, and Cycle II assessments with no attrition. Instruction involved teacher explanation and demonstration, paired rubber-ball practice, repetition, feedback, and reinforcement of initial stance, execution, and final stance. Performance was assessed on a 0–100-point criterion-referenced scale; individual mastery was ≥75 points and classical mastery was ≥85% of students achieving mastery. Data were analysed using descriptive statistics, paired-samples t-tests with 95% confidence intervals and Cohen's dz, and one-way repeated-measures ANOVA with partial eta squared (ηp^2).

Results: Mastery increased from 10/34 students (29.41%) at pre-cycle to 26/34 (76.47%) in Cycle I and 30/34 (88.24%) in Cycle II, an overall increase of 58.82 percentage points and achievement of the ≥85% classical-mastery target. Mean performance increased from 67.94 ± 8.23 to 79.15 ± 9.02 and 83.56 ± 8.71 points. Pre-cycle to Cycle I improvement was 11.21 points (95% CI 9.74–12.68; $t(33)=15.51$; $p<.001$; $dz=2.66$), and Cycle I to Cycle II improved by 4.41 points (95% CI 3.54–5.29; $t(33)=10.24$; $p<.001$; $dz=1.76$). Overall improvement was 15.62 points (95% CI 14.01–17.22; $t(33)=19.80$; $p<.001$; $dz=3.40$); the repeated-measures effect was significant, $F(2,66)=292.53$, $p<.001$, $\eta p^2=.899$.

Conclusions: Rubber-ball-based instruction was associated with substantial within-classroom improvement and enabled the class to exceed its predefined mastery target. Internationally, the study provides a feasible low-cost equipment-adaptation strategy for primary PE, while controlled multisite studies are needed to establish causal effects and retention.

Keywords
volleyball; underhand passing; physical education; motor skill; classroom action research; elementary school students.

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INTRODUCTION

Physical education (PE) is an important setting for developing children's movement competence, confidence, and opportunities for sustained participation in physical activity. Motor competence is not an isolated performance construct: international evidence indicates meaningful relationships between motor competence and physical activity, physical fitness, and psychosocial characteristics across childhood and adolescence (Burton et al., 2023).(Lima et al., 2017, p. 452). A recent systematic review of elementary-school interventions found moderate-to-large pre–post improvements in motor competence across school-based physical-activity programs, while also highlighting substantial heterogeneity in intervention content, assessment, and context (Barnett et al., 2016, p. 1685; Neil-Sztramko et al., 2021; Sun & Chen, 2024). These findings place the quality of everyday PE instruction, rather than only the quantity of physical activity, at the center of children's movement development.

Within school PE, ball games provide a particularly useful context because they require children to coordinate perception, movement, timing, force, and interaction with peers (Moon et al., 2024, p. 835; Petrušič, 2023). Volleyball is an instructive example. Underhand passing, or the forearm pass, is a core skill for receiving and controlling a ball and is often a prerequisite for successful participation in modified volleyball games (Batez et al., 2021; Zhu et al., 2026). Research in school settings has shown that volleyball skills can improve through structured instructional programs. For example, a controlled school intervention using Teaching Games for Understanding (TGfU) reported improvements in forearm-passing performance Batez et al. (2021), while a 2024 study of a modified TGfU program in elementary-school students reported significantly better forearm-passing outcomes than traditional PE instruction (Ariwibowo et al., 2024). Earlier experimental work also showed that repeated ball-skill practice can improve children's ball skills (Westendorp et al., 2013). Together, these findings indicate that the instructional environment and practice design matter for skill acquisition, although the evidence is not specific to rubber-ball media.

A theoretically plausible mechanism for modifying the learning environment is the constraints-led perspective on motor learning(Guo & Cheng, 2026, p. 2; Renshaw et al., 2010). In this framework, movement solutions emerge from the interaction of learner, task, and environmental constraints. Equipment is therefore not a neutral object: its size, weight, stiffness, speed, and rebound characteristics can alter the perceptual and biomechanical demands placed on the learner (Dancy & Murphy, 2020, p. 2432; Liu, 2023, p. 3). A systematic review of equipment and play-area scaling in children's sport found that children generally performed skills better with appropriately scaled equipment, and some studies suggested greater engagement and faster skill acquisition (Buszard et al., 2016). The evidence base nevertheless remains limited because relatively few studies examined learning longitudinally and because many studies used short practice periods or laboratory-like skill tests. For underhand passing in primary school, a softer and lighter rubber ball can be interpreted as a task modification intended to lower the initial difficulty of ball contact(Abswoude et al., 2021, p. 2593; French et al., 1991, p. 274). The expected pathway is not simply that a rubber ball is 'easier'; rather, reduced perceived threat and manageable ball behavior may allow children to allocate more attention to the sequence of the movement—ready position, platform formation, controlled contact, and follow-through—while obtaining more successful repetitions(Capio et al., 2016, 2021, p. 678876). Repetition is important because motor learning requires opportunities to detect errors, receive feedback, and stabilize movement solutions. Evidence from school-based ball-skill interventions supports the value of structured and repeated practice Westendorp et al. (2013), while qualitative research in primary PE suggests that teaching conditions, teacher feedback, and the learning environment influence how children engage with fundamental movement skills (Chan et al., 2022). However, existing evidence leaves several important questions unresolved. First, much of the international literature evaluates formal intervention programs, game-based pedagogies, or scaled equipment in sports other than volleyball, rather than a low-cost rubber-ball adaptation embedded in routine classroom PE. Second, studies differ substantially in age, skill level, intervention dose, outcome measures, and analytic strategy. Controlled studies can estimate between-group effects, but they may not capture the iterative problem-solving process that characterizes classroom action research. Conversely, classroom action research is well suited to identifying whether a practical change improves learning in a real class, but its findings are inherently more context-bound and should not be interpreted as equivalent to controlled causal evidence. Third, many school-based reports emphasize statistical significance without sufficiently reporting effect magnitude, uncertainty, fidelity, or whether a predefined mastery criterion was actually reached.

The present study addresses this practical and methodological gap by examining a low-cost equipment modification—rubber-ball practice—for underhand passing among Grade 4 students. The study is intentionally framed as classroom action research rather than as a controlled efficacy trial. This distinction is important because the research question is primarily one of instructional improvement: can a feasible change in the learning environment increase the number of children who meet the school's predefined performance criterion? The novelty lies in documenting the first completed action cycle in an authentic primary-school PE setting and explicitly linking the intervention rationale to the broader international literature on motor competence and equipment scaling. Although previous studies show that structured PE interventions, ball-skill practice, and appropriately scaled equipment can support children's motor performance, it remains unclear whether a simple rubber-ball adaptation can increase the proportion of primary-school learners meeting a predefined underhand-passing criterion within a routine classroom action cycle. This study therefore contributes a practice-oriented case of how task constraints can be modified in a resource-conscious setting. Its international relevance is not a claim of generalizability from one class, but a transferable pedagogical proposition that can be tested in other schools, countries, and volleyball-learning contexts.

Global and Theoretical Context

The central theoretical proposition is that children's skill learning is shaped by the interaction between individual capabilities and the constraints imposed by the task and environment (Buszard et al., 2016; Roberts et al., 2018, p. 167; Sigmundsson et al., 2021, p. 631181). For a novice learner, a standard volleyball may create demands that exceed current strength, timing, or confidence, increasing unsuccessful contacts and reducing opportunities for productive repetition(Correia et al., 2018, p. 129; Moy et al., 2024). A softer or lighter ball may change the task constraint sufficiently to make the movement more achievable while preserving the essential perception–action relationship of passing. The expected effect is therefore an increase in successful practice opportunities and more stable execution, rather than an automatic improvement simply attributable to the material of the ball.

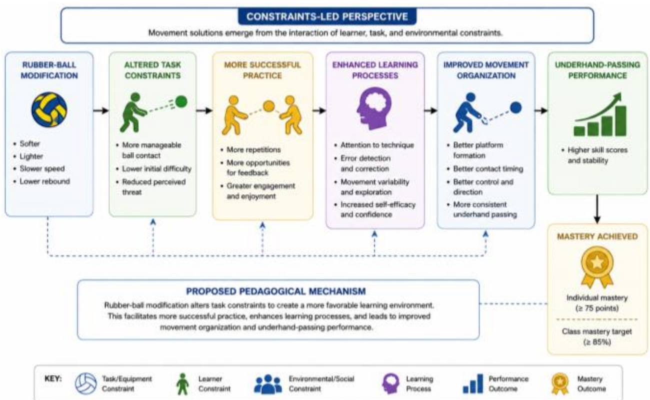


Figure 1. Conceptual Pathway of Rubber-Ball-Based Instruction for Volleyball Underhand-Passing Learning

Figure 1 presents the proposed conceptual pathway underlying the use of rubber-ball media in primary-school volleyball instruction. From a constraints-led perspective, modifying the physical properties of the ball may alter the task constraints experienced by learners, potentially making ball contact and movement execution more manageable during the early stages of skill acquisition. A more manageable task may provide greater opportunities for successful practice, repetition, and teacher feedback (Chow et al., 2025; Liu, 2023, p. 3). These learning conditions are proposed to facilitate attention to technical components, error detection and correction, and progressive organization of the underhand-passing movement (Sidaway et al., 2012). The expected outcome is improved movement execution and underhand-passing performance, followed by a greater proportion of students reaching the individual mastery criterion (≥75 points) and the predefined classical-mastery target (≥85% of students). Because the present study did not directly measure perceived difficulty, confidence, motivation, practice repetitions, movement variability, or cognitive load, the pathway should be interpreted as a theoretically informed pedagogical proposition rather than a directly tested mediation mechanism.

Critical Review of Existing Evidence

International evidence supports the broader logic but also demonstrates why stronger methodological caution is required. Buszard et al. (2016, p. 841) synthesized 25 studies involving 989 children and found that scaled equipment generally improved skill performance, with some evidence of greater engagement and faster acquisition; however, only five studies directly examined learning over time. Sun & Chen (2024) likewise reported moderate-to-large effects of sports-game interventions on children's fundamental motor skills, while emphasizing heterogeneity across study design and context. Westendorp et al. (2013) demonstrated that a 16-week ball-skill intervention improved ball skills in children with learning disorders, illustrating the value of repeated practice but involving a different population and intervention structure. In volleyball specifically, Batez et al. (2021) reported improved forearm passing following a six-week TGfU program, and Ariwibowo et al. (2024) found superior forearm-passing outcomes with a modified TGfU model compared with traditional PE instruction in elementary-school students.

These studies differ from the present action research in several ways. They typically use experimental or quasi-experimental comparisons, larger samples, longer intervention periods, or validated performance tests. Such designs are stronger for estimating comparative effects but may be less directly aligned with the iterative improvement cycle of a single classroom (Koedinger et al., 2013; Raver et al., 2007, p. 12). The present study instead uses the classroom as the unit of change and a school-defined mastery threshold as the primary outcome. This makes the result immediately actionable for the teacher but reduces external validity and prevents a strong causal attribution (Allen et al., 2011, p. 1037). The literature therefore suggests a complementary position: classroom action research can generate ecologically valid improvement evidence, while subsequent controlled studies are needed to estimate the independent effect of rubber-ball use.

Research Gap, Novelty, and International Contribution

The unresolved issue is whether a simple, inexpensive equipment modification can improve mastery of underhand passing among primary-school children when implemented as part of normal PE instruction. The study's novelty is the integration of rubber-ball practice into a real classroom action cycle, with a clearly defined individual mastery threshold and a classical mastery target. The international contribution is modest but useful: it provides a replicable pedagogical hypothesis that equipment scaling can be used as a low-cost first-line adaptation in school volleyball instruction, while also demonstrating the methodological limits that must be addressed in future comparative research.

Objectives and Hypotheses

Primary objective: to determine whether the first completed classroom action cycle using rubber-ball media increases the proportion of Grade 4 students achieving the predefined mastery criterion (score ≥75) for volleyball underhand passing. Secondary objectives were to describe the distribution of Cycle I scores and determine whether the observed proportion of students meeting the criterion reached the prespecified classical mastery target of 85%.

Working hypothesis: the proportion of students achieving the underhand-passing mastery criterion will increase after implementation of rubber-ball practice. Because this is a one-group classroom action study without a comparator and without individual-level transition data in the available dataset, the hypothesis is evaluated descriptively rather than through a confirmatory causal significance test.

MATERIALS FOR ANALYSIS

Research Design and Reporting Framework

This study employed a Classroom Action Research (CAR) design to examine the improvement of volleyball underhand-passing performance following the implementation of rubber-ball-based learning activities in a Grade 4 physical education class. The study used an iterative instructional improvement framework consisting of planning, action, observation, and reflection.

The research was conducted prospectively within the students' regular physical education learning environment. A baseline assessment was conducted during the pre-cycle stage, followed by the implementation and assessment of Cycle I and Cycle II. Each cycle involved instructional implementation, observation of student performance, assessment of the targeted motor skill, and reflection to identify areas requiring further instructional refinement.

The study used a single intact classroom without randomization or a parallel comparator group. Therefore, the design was intended to evaluate within-classroom changes across successive action-research stages rather than to establish a randomized causal treatment effect. The manuscript was prepared with reference to principles of transparent reporting for educational improvement research, including SQUIRE-EDU, while the description of the intervention was structured with reference to TIDieR principles to improve reproducibility. The primary outcome was criterion-based mastery of volleyball underhand passing, defined as achieving a score of ≥75 points. The predefined criterion for classical mastery was ≥85% of participating students achieving individual mastery.

Setting and Participants

The study was conducted in a Grade 4 class at State Elementary School 163097, Tebing Tinggi, Indonesia, during the 2024/2025 academic year. The study population comprised the students enrolled in the participating Grade 4 class.

A total of 34 students participated in the study. The inclusion criterion was enrollment in the participating Grade 4 class and participation in the volleyball underhand-passing learning activities during the study period. No additional exclusion criteria were applied to enrolled students.

All 34 students completed the pre-cycle assessment and participated in the subsequent Cycle I and Cycle II assessments. No participant withdrew, was excluded, replaced, or lost to follow-up during the reported study period. Consequently, the final longitudinal analysis included all 34 students.

The study used the intact classroom as the unit of implementation. No individual randomization was performed and no parallel comparator group was included. The intervention was delivered within the students' regular physical education learning environment to preserve the authenticity of the classroom instructional context.

Individual participant characteristics, including age and sex distribution, were not included in the available analytical dataset and therefore are not reported.

Action Research Cycles

The action research consisted of a pre-cycle assessment followed by two iterative action cycles. Each action cycle followed four stages: planning, action, observation, and reflection.

Pre-cycle

The pre-cycle assessment established the students' baseline performance in volleyball underhand passing before the implementation of the rubber-ball-based instructional approach. The assessment used the same general technical criteria subsequently applied during Cycle I and Cycle II.

Cycle I

During the planning stage of Cycle I, the researcher prepared the learning activities, rubber-ball media, instructional procedures, observation materials, and performance-assessment criteria. During the action stage, the teacher explained and demonstrated the fundamental underhand-passing technique. Students then practised the movement using rubber balls, primarily through paired activities. The practice emphasized the preparatory position, execution of the passing movement, and final position. During the observation stage, student participation and technical performance were observed during the instructional activities. Following the intervention, students completed the underhand-passing performance assessment. During reflection, the assessment findings and observed learning difficulties were reviewed to identify aspects requiring further instructional improvement.

Cycle II

Cycle II was implemented as a continuation of the action-research process following reflection on Cycle I. The purpose of the second cycle was to reinforce the underhand-passing movement and provide additional opportunities for practice and correction of remaining technical difficulties. The Cycle II instructional process followed the same four-stage structure of planning, action, observation, and reflection. Students continued to practise the underhand-passing movement using rubber-ball media, with instructional attention directed toward improving technical execution and reinforcing correct movement patterns. The Cycle II assessment was conducted using the same outcome definition and general assessment procedure used at the preceding stages. The action-research process was considered to have achieved its predefined classroom-level success criterion when at least 85% of students obtained scores ≥75.

Intervention and Fidelity

The intervention consisted of incorporating rubber-ball media into volleyball underhand-passing instruction. The intervention was designed to provide students with repeated opportunities to practise the fundamental passing movement using an accessible and child-adapted ball. Instruction addressed three principal components of the underhand-passing technique: 1) Initial stance, including appropriate body and lower-limb positioning before ball contact; 2) Execution, including formation of the forearm platform, controlled ball contact, and direction of the pass; and 3) Final stance, including continuation of the movement and maintenance of appropriate body position following contact.

Students primarily practised in pairs. The reported practice arrangement involved students facing one another at an approximate distance of 3 m. One student delivered the ball to the partner, who performed the underhand pass, after which the activity was repeated.

The intervention incorporated teacher explanation and demonstration followed by repeated student practice. The instructional process was conducted within the regular physical education learning environment rather than under laboratory conditions. Two teacher-assessors participated in the assessment process. Before assessment, both assessors received a briefing regarding the assessment criteria, scoring procedures, and technical components to be evaluated. The same assessment criteria were applied across the pre-cycle, Cycle I, and Cycle II assessments. Intervention fidelity was monitored through observation of the planned learning activities. The intervention components included teacher explanation and demonstration, rubber-ball practice, paired practice, observation of student performance, and post-intervention skills assessment.

The available research records did not include a formal numerical fidelity score or a standardized quantitative adherence index. Therefore, fidelity is reported descriptively rather than as a percentage. No participant withdrawal or replacement was recorded, and complete outcome data were available for all 34 students across all three assessment stages.

Outcome Measures

The primary outcome was volleyball underhand-passing performance, assessed using a criterion-referenced skills assessment.

Each student performed 10 underhand-passing attempts while working with a partner at an approximate distance of 3 m. Performance was evaluated using three technical components: 1) initial stance; 2) execution of the passing movement; and 3) final stance.

The performance assessment generated a score on a 0–100-point scale. A score of ≥75 was classified as individual mastery, whereas a score below 75 was classified as non-mastery.

The primary categorical outcome was therefore the proportion of students achieving mastery at each assessment stage. The continuous underhand-passing score was treated as a secondary outcome to characterize the magnitude and trajectory of performance change across the three stages. Assessments were conducted at three time points: 1) Pre-cycle: baseline assessment before implementation of the action intervention;2) Cycle I: assessment following the first action cycle; and3) Cycle II: assessment following the second action cycle. The predefined criterion for classical mastery was ≥85% of students achieving individual mastery.

Validity and Reliability

The underhand-passing performance assessment was conducted by two teacher-assessors using the same assessment criteria and scoring procedures. Before the assessments, both assessors received a standardized briefing concerning the technical components of the underhand-passing movement, the scoring criteria, and the assessment procedure.

The assessment criteria were aligned with the instructional objectives and focused on observable technical components of the underhand-passing movement, namely the initial stance, execution, and final stance. Both assessors evaluated student performance using the same criteria. The use of two assessors was intended to reduce reliance on a single assessor's judgment and to promote consistency in performance evaluation. The assessors conducted the assessment directly within the physical education learning context.

The available research records did not include a formal quantitative inter-rater reliability coefficient. Consequently, no ICC, Cohen's kappa, or other reliability coefficient is reported. Similarly, no confidence interval for an inter-rater reliability estimate is reported. The assessment was not conducted using video-based blinded rescoring. Both assessors were aware of the assessment stage during the classroom-based assessment process. Therefore, assessor-related measurement variability and potential stage-related judgment bias cannot be completely excluded and are considered in the interpretation of the findings.

Data Analysis

Data were analysed using IBM SPSS Statistics, version 28. The analysis combined descriptive and inferential procedures to examine changes in underhand-passing performance across the three assessment stages.

Descriptive statistics included sample size (n), frequency and percentage of students achieving mastery, mean, standard deviation (SD), median, minimum, and maximum scores. Individual mastery was defined as a score of ≥ 75, and classical mastery was defined as at least 85% of students achieving the individual mastery criterion.

Changes in the proportion of students achieving mastery were expressed as absolute percentage-point changes between assessment stages. The progression of continuous performance scores was evaluated using paired comparisons between pre-cycle and Cycle I, Cycle I and Cycle II, and pre-cycle and Cycle II.

For paired comparisons, the paired-samples t-test was used to evaluate mean within-student changes. Mean differences were reported with 95% confidence intervals (CIs). The magnitude of within-student change was quantified using Cohen's dz, calculated from the paired mean difference and the standard deviation of the paired differences.

To evaluate the overall change across the three repeated assessment stages, a one-way repeated-measures analysis of variance (ANOVA) was performed. The overall effect was reported using partial eta squared (ηp^2) as the effect-size measure.

The assumptions underlying the parametric analyses were evaluated before interpretation of the inferential results. Because the same 34 students were assessed at all three stages, the analyses accounted for the repeated-measures structure of the data.

The statistical significance level was set at $\alpha = .05$, and all inferential tests were two-sided. Exact p-values were reported where available, except where $p < .001$ was appropriate. No value was reported as $p = .000$.

All 34 participants had complete outcome observations across the three assessment stages; therefore, no participant-level imputation for missing outcome data was required. Individual score distributions were inspected for extreme values before inferential analysis. The observed score ranges were retained in the analysis because no observations were excluded solely on the basis of their magnitude. Because the study used a single intact classroom without a control group, the inferential analyses were interpreted as evidence of within-classroom longitudinal change rather than evidence of an independently estimated causal effect of the rubber-ball intervention.

Ethics and Consent

The study involved Grade 4 elementary-school students and was conducted in accordance with the ethical requirements of the Ethics Research Committee of STOK Bina Guna. Ethical approval was granted under approval number STOK/Research/Skripsi-2775 on 11 January 2026. Permission to conduct the study was obtained from the participating elementary school before the research activities were initiated.

The study was conducted within the regular physical education learning context and involved the students enrolled in the participating Grade 4 class. Individual written informed consent from parents or legal guardians was not documented in the available research records. Participation was conducted under institutional ethical approval and school authorization. The students were informed about the learning activities and research procedures in language appropriate to their age.

Participant confidentiality was maintained throughout the study. Students' names and directly identifying information were not included in the manuscript or analytical dataset. Results were reported in aggregate form. No identifiable photographs, videos, or individual case descriptions are included in the present manuscript. Consequently, no separate publication consent for identifiable participant materials was required for the materials reported in this article. The authors confirm that the ethical information reported in this manuscript reflects the available institutional documentation and actual research procedures. No fabricated ethics approval, consent status, exemption status, or participant information has been included.

RESULTS

Participant Flow

A total of 34 Grade 4 students from the participating class were included in the study. All 34 students completed the pre-cycle assessment and participated in the subsequent Cycle I and Cycle II assessments. No participant was excluded, withdrawn, replaced, or lost during the reported study period.

Thus, the analysis population remained constant across all three assessment stages: pre-cycle (n = 34), Cycle I (n = 34), and Cycle II (n = 34). Complete outcome records were available for all 34 students, resulting in 100% longitudinal outcome completeness.

Because the study employed a classroom action research design using an intact class, no individual randomization was performed and no parallel comparator group was included.

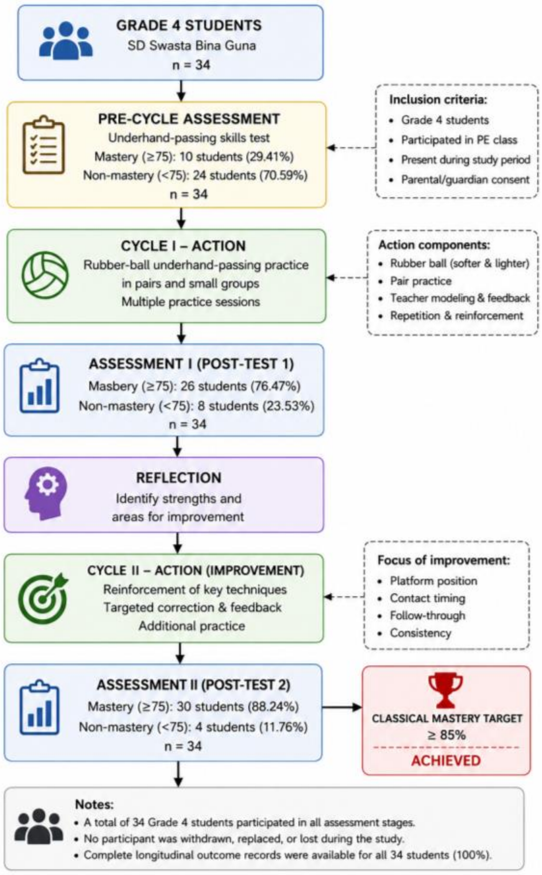


Figure 2. Participant flow through the classroom action research.

Baseline/Pre-cycle

At baseline, the mean volleyball underhand-passing score was 67.94 ± 8.23 points, with a median of 69.0 points and a range of 45–79 points. Using the predefined mastery criterion of ≥75 points, 10 of 34 students (29.41%) achieved individual mastery, whereas 24 students (70.59%) did not. The baseline mastery rate was therefore substantially below the predefined classical-mastery criterion of 85%. The 95% Wilson confidence interval for the baseline mastery proportion was 16.83%–46.17%.

Table 1. Descriptive Characteristics of Underhand-Passing Performance Across the Action-Research Stages

Assessment stage	n	Mastery, n (%)	Mean ± SD	Median	Range	95% CI for mastery
Pre-cycle	34	10 (29.41%)	67.94 ± 8.23	69.0	45–79	16.83–46.17%
Cycle I	34	26 (76.47%)	79.15 ± 9.02	80.0	55–94	60.00–87.56%
Cycle II	34	30 (88.24%)	83.56 ± 8.71	84.5	60–99	73.38–95.33%

Note. Mastery was defined as a score of ≥75. Classical mastery was predefined as ≥85% of students achieving individual mastery. CI = confidence interval.

Cycle I

Following implementation of the rubber-ball-based learning activities, underhand-passing performance improved during Cycle I.

The mean score increased from 67.94 ± 8.23 points at pre-cycle to 79.15 ± 9.02 points in Cycle I, representing a mean within-student increase of 11.21 points (95% CI, 9.74–12.68). The corresponding paired-samples analysis indicated a statistically significant increase, $t(33) = 15.51$, $p < .001$, with a very large paired effect size (Cohen's dz = 2.66). The median score increased from 69.0 to 80.0 points, while the observed range shifted from 45–79 points at baseline to 55–94 points in Cycle I. Criterion-based mastery also increased substantially. The number of students achieving a score of ≥75 increased from 10 (29.41%) to 26 (76.47%), representing an absolute increase of 47.06 percentage points. Despite this improvement, the Cycle I mastery rate remained below the predefined classical-mastery criterion of 85%.

Cycle II

Following reflection on Cycle I, the instructional process was continued with further opportunities for practice and reinforcement of the underhand-passing movement. Cycle II demonstrated a further improvement in performance. The mean score increased from 79.15 ± 9.02 points in Cycle I to 83.56 ± 8.71 points in Cycle II, corresponding to an additional mean increase of 4.41 points (95% CI, 3.54–5.29). The paired comparison indicated a statistically significant improvement, $t(33) = 10.24$, $p < .001$, with a large paired effect size (Cohen's dz = 1.76). The median score increased from 80.0 to 84.5 points, and the observed range shifted from 55–94 points in Cycle I to 60–99 points in Cycle II. The number of students achieving the mastery criterion increased from 26 (76.47%) in Cycle I to 30 (88.24%) in Cycle II, corresponding to an additional increase of 11.77 percentage points. Importantly, the Cycle II mastery rate exceeded the predefined classical-mastery criterion of 85%. Thus, the action-research success criterion was achieved at the end of Cycle II.

Primary Outcome

The primary outcome was criterion-based mastery of volleyball underhand passing, defined as achieving a score of ≥75 points. A progressive increase in mastery was observed across the three assessment stages. Mastery increased from 10/34 students (29.41%) at pre-cycle, to 26/34 (76.47%) in Cycle I, and finally to 30/34 (88.24%) in Cycle II. The overall increase from pre-cycle to Cycle II was therefore 58.82 percentage points, corresponding to an additional 20 students achieving mastery compared with baseline.

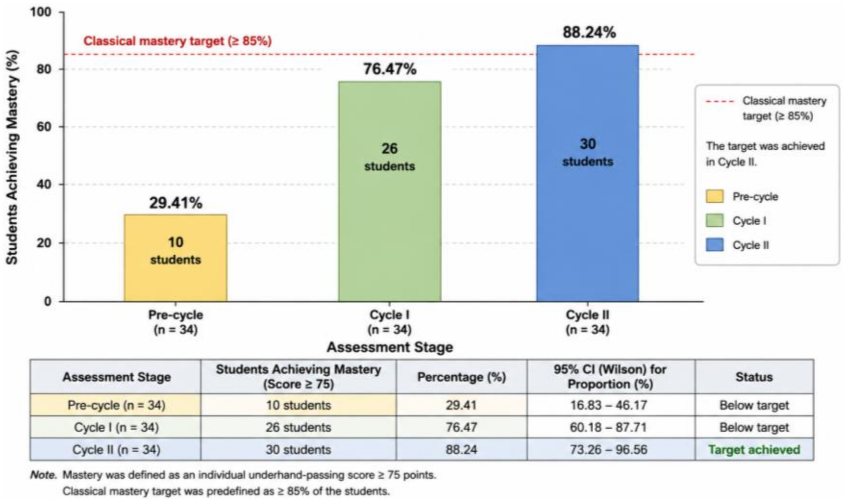


Figure 3. Progression of Students Achieving the Predefined Mastery Criterion (≥75 Points) Across Action-Research Stages. The proportion of students achieving individual mastery increased from 29.41% (10/34) at pre-cycle to 76.47% (26/34) in Cycle I and 88.24% (30/34) in Cycle II. The predefined classical-mastery target of ≥85% was reached only at the end of Cycle II.

Figure 3 shows a progressive increase in mastery across the action-research stages, from 29.41% at pre-cycle to 76.47% in Cycle I and 88.24% in Cycle II. The predefined classical-mastery target of ≥85% was achieved only in Cycle II, when 30 of 34 students reached the individual mastery criterion of ≥75 points. The 95% Wilson confidence interval for the mastery proportion was 16.83–46.17% at pre-cycle, 60.00–87.56% in Cycle I, and 73.38–95.33% in Cycle II.

Table 2. Primary Outcome: Mastery Progression

Assessment stage	Mastery n/N	Mastery (%)	Not mastery n/N	Not mastery (%)	Difference from 85% criterion
Pre-cycle	10/34	29.41	24/34	70.59	−55.59 pp
Cycle I	26/34	76.47	8/34	23.53	−8.53 pp
Cycle II	30/34	88.24	4/34	11.76	+3.24 pp

Note. pp = percentage points. Mastery was defined as ≥75 points; classical mastery was defined as ≥85% of students achieving individual mastery.

The transition analysis further showed that 16 students who had not achieved mastery at pre-cycle reached mastery by Cycle I, while all 10 students who had already achieved mastery at baseline remained above the criterion in Cycle I. Between Cycle I and Cycle II, 4 of the 8 students who had not achieved mastery in Cycle I subsequently reached mastery, while the 26 students who had achieved mastery in Cycle I remained above the criterion.

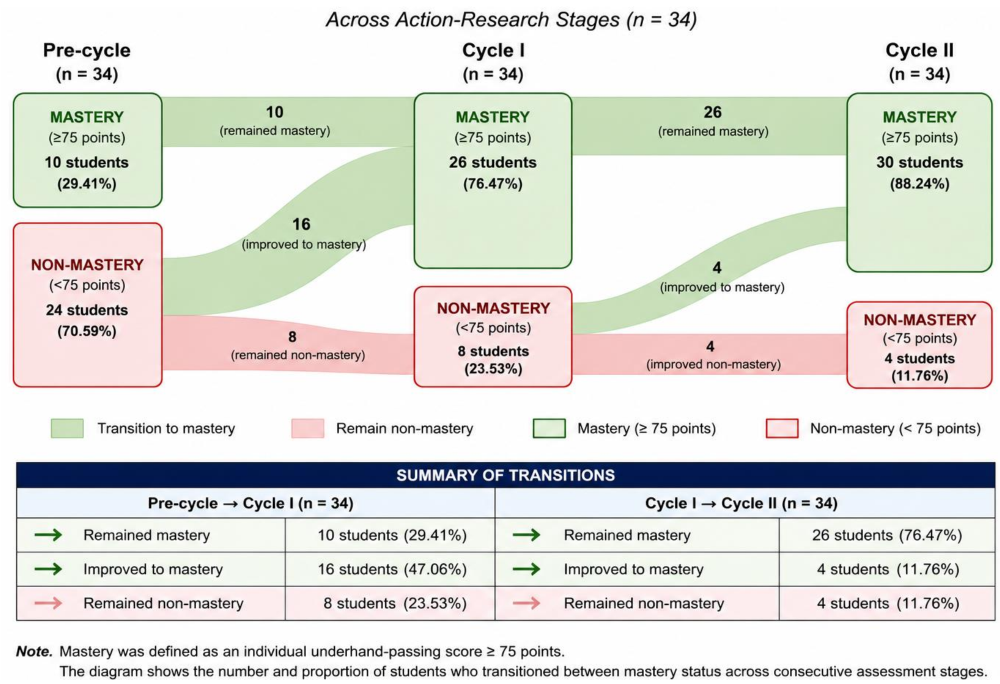
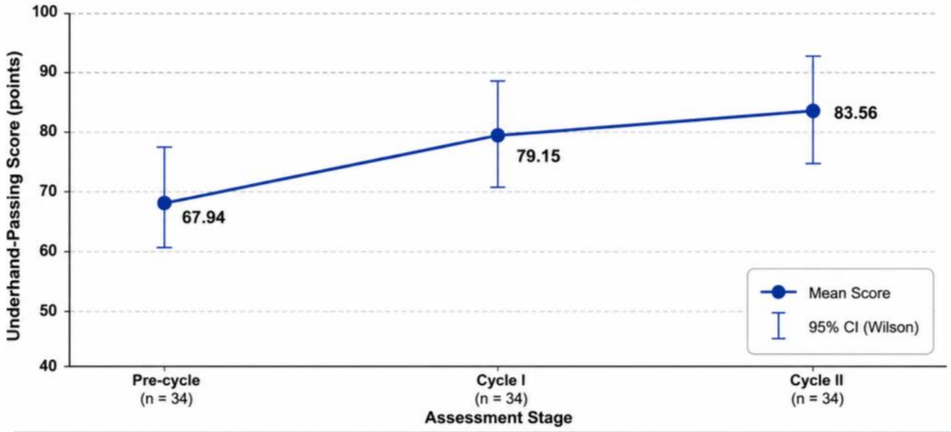


Figure 4. Individual Student Transitions Across the Mastery Threshold (≥75 Points)

Figure 4 shows a progressive movement of students across the mastery threshold. From pre-cycle to Cycle I, 16 previously non-mastered students reached mastery, while all 10 students who were initially mastered remained above the criterion. From Cycle I to Cycle II, four additional students reached mastery, resulting in 30 of 34 students achieving the criterion. The number of non-mastered students consequently decreased from 24 at baseline to 8 after Cycle I and 4 after Cycle II.

Secondary Outcomes

The secondary outcome was the continuous underhand-passing performance score. Mean performance increased progressively from 67.94 points at pre-cycle to 79.15 points in Cycle I and 83.56 points in Cycle II. The overall mean increase from pre-cycle to Cycle II was 15.62 points (95% CI, 14.01–17.22).



Assessment Stage	Pre-cycle (n = 34)	Cycle I (n = 34)	Cycle II (n = 34)
Mean ± SD (points)	67.94 ± 8.23	79.15 ± 9.02	83.56 ± 8.71
Median (points)	69.0	78.0	84.0
Range (points)	45–79	50–93	56–96
Improvement from previous stage	–	+11.21 points (↑ 16.5%)	+4.41 points (↑ 5.6%)

Note: Error bars represent the 95% Wilson confidence interval for the mean.

Figure 3. Longitudinal Trajectory of Volleyball Underhand-Passing Performance Across Action-Research Stages

Interpretation of Figure 5. Figure 3 illustrates a progressive increase in volleyball underhand-passing performance across the three assessment stages. The mean score increased from 67.94 ± 8.23 points at pre-cycle to 79.15 ± 9.02 points in Cycle I and further to 83.56 ± 8.71 points in Cycle II. The largest improvement occurred between the pre-cycle and Cycle I, with a mean increase of 11.21 points, whereas a further increase of 4.41 points was observed between Cycle I and Cycle II. Overall, the mean score increased by 15.62 points from pre-cycle to Cycle II. The pattern indicates a positive longitudinal trajectory of underhand-passing performance throughout the classroom action research process. However, because the study used a single intact classroom without a comparator group, this trajectory should be interpreted as evidence of within-classroom improvement rather than definitive evidence that the rubber-ball intervention alone caused the observed change. A repeated-measures analysis of variance demonstrated a statistically significant effect of assessment stage on underhand-passing scores, $F(2,66) = 292.53$, $p < .001$, with a very large effect size (partial $\eta^2 = .899$).

Table 3. Longitudinal Change in Continuous Underhand-Passing Performance

Comparison	Mean change	95% CI	*t*(33)	*p*	Cohen's *dz*
Pre-cycle → Cycle I	+11.21	9.74 to 12.68	15.51	<.001	2.66
Cycle I → Cycle II	+4.41	3.54 to 5.29	10.24	<.001	1.76
Pre-cycle → Cycle II	+15.62	14.01 to 17.22	19.80	<.001	3.40

Note. CI = confidence interval. Cohen's *dz* was calculated from the paired mean difference and the standard deviation of the paired differences. All tests were two-sided with α = .05.

The magnitude of the improvement was greatest during the initial transition from pre-cycle to Cycle I, followed by a smaller but still statistically significant improvement between Cycle I and Cycle II.

Fidelity and Adherence

All 34 students had complete outcome observations across the three assessment stages, resulting in 100% completeness of the longitudinal outcome dataset. No participant withdrawal, replacement, or loss was recorded. The intervention was implemented using rubber-ball-based underhand-passing practice within the classroom action research process. The instructional activities included teacher explanation and demonstration, paired practice, repeated performance of the underhand-passing movement, and assessment of the initial stance, execution, and final position. The available dataset confirms implementation across the reported action-research stages but does not provide a quantitative intervention-fidelity score, attendance percentage, exact number of repetitions, or standardized adherence score. Therefore, these variables were not assigned numerical values.

Table 4. Participant Completeness and Intervention-Fidelity Indicators

Indicator	Result
Pre-cycle assessment completed	34/34 (100%)
Cycle I assessment completed	34/34 (100%)
Cycle II assessment completed	34/34 (100%)
Complete longitudinal records	34/34 (100%)
Participant withdrawal	None recorded
Participant replacement	None recorded
Outcome missingness	0%
Rubber-ball intervention implemented	Yes
Paired practice implemented	Yes
Teacher explanation/demonstration	Yes
Formal fidelity score	Not available

Quantitative adherence rate	Not available
Protocol deviations	Not quantitatively documented
Adverse events	None reported

The complete outcome dataset permitted longitudinal comparison across all three action-research stages. Nevertheless, the absence of quantitative fidelity and adherence measures limits the ability to determine whether variations in implementation intensity contributed to the observed changes in student performance.

DISCUSSION

Principal Findings

This study examined whether an iterative classroom action research process incorporating rubber-ball-based practice could improve Grade 4 students' volleyball underhand-passing performance. The principal finding was a consistent improvement across the three assessment stages. Mean performance increased from 67.94 points at pre-cycle to 79.15 points in Cycle I and 83.56 points in Cycle II, while criterion-based mastery increased from 29.41% to 76.47% and subsequently to 88.24%. The predefined classical-mastery criterion of 85% was therefore achieved only after Cycle II.

The magnitude of the observed changes was substantial. The pre-cycle-to-Cycle I improvement was 11.21 points, followed by a further 4.41-point increase from Cycle I to Cycle II. The corresponding paired effect sizes were very large (dz = 2.66 and 1.76, respectively), while the overall pre-cycle-to-Cycle II effect was also very large (dz = 3.40). These findings indicate that the improvement was not limited to a small increase in the proportion of students crossing the mastery threshold; the continuous performance scores also shifted progressively upward.

Importantly, the pattern of improvement is consistent with the logic of classroom action research. The largest gain occurred during the initial transition from baseline to Cycle I, whereas the second cycle produced a smaller but still statistically significant gain. This pattern suggests that the first exposure to the modified learning environment may have addressed substantial barriers to initial skill performance, while the second cycle provided an opportunity to consolidate and refine the movement pattern. Nevertheless, because the study did not include a control group, the observed improvement should be interpreted as within-classroom longitudinal change associated with the action-research process, rather than as definitive evidence that the rubber ball alone caused the improvement.

The findings also have practical significance. By Cycle II, 30 of 34 students had reached the predefined mastery threshold. Thus, the intervention process succeeded in moving the class beyond its predetermined 85% criterion. From an educational perspective, this is more meaningful than statistical significance alone because the criterion was defined in advance as an indicator of successful classroom learning.

Comparison with International Evidence

The present findings are broadly consistent with international evidence showing that children's motor-skill performance can benefit when learning environments are adapted to their developmental characteristics. A systematic review by Buszard et al. (2016, p. 829) examined 25 studies involving 989 children and found that scaled equipment and playing environments generally improved children's skill performance, engagement, self-efficacy, and, in some studies, the rate of skill acquisition. Importantly, the authors also noted that evidence for actual long-term skill learning remained more limited than evidence for immediate performance(Levac & Lu, 2018, p. 207; Zask et al., 2012, p. 133). This distinction is particularly relevant to the present study because the improvement was observed across successive classroom assessments rather than through a delayed retention test (Buszard et al., 2016.

The present study extends this literature in two ways. First, the modification involved a rubber ball within ordinary primary-school physical education, rather than a laboratory-based motor-learning task(Brocken et al., 2021, p. 653010). Second, the intervention was embedded in an iterative classroom action research process in which instructional decisions were revised after each cycle. This ecological feature is important because evidence from controlled motor-learning studies does not always translate directly into the constraints of real classrooms, where teachers must simultaneously manage equipment, student differences, instructional time, and engagement(Abswoude et al., 2021, p. 2593).

The findings are also compatible with evidence that equipment scaling can influence the quality of children's movement solutions. Buszard et al. (2014) reported that less-skilled children experienced greater difficulty when using full-size sporting equipment, whereas scaled equipment reduced some of the demands associated with the task and promoted more implicit forms of motor processing (doi:10.1016/j.concog.2014.07.004). Although the present study did not directly measure cognitive load, anxiety, or movement variability, the progressive improvement observed after introducing a more accessible ball is compatible with the proposition that modifying task constraints can make a movement problem more manageable for children (Dancy & Murphy, 2020, p. 2432; Guo & Cheng, 2026, p. 2).

This interpretation is also consistent with the constraints-led approach, which conceptualizes skill acquisition as an interaction among individual, task, and environmental constraints. In physical education, manipulating task constraints can alter the opportunities available for exploration and successful movement solutions Renshaw et al. (2010). More recent volleyball research provides a direct sport-specific example: a modified practice constraint involving an additional serve opportunity increased high-school students' confidence and exploration during volleyball performance, suggesting that carefully designed task constraints can facilitate motor-skill exploration(Moy et al., 2024).

From this perspective, the rubber ball should not be viewed simply as an alternative piece of equipment. It may function as a task constraint modification that changes the difficulty of the movement problem encountered by the learner (Baggs et al., 2020, p. 1960; Komar et al., 2023, p. 2017). For primary-school students who are still developing coordination, postural control, and ball-handling competence, a more manageable ball may create more opportunities to organize the body, establish an appropriate forearm platform, contact the ball successfully, and immediately attempt the movement again (Buszard et al., 2016, p. 837; Pellett et al., 1994).

The present findings are further consistent with recent evidence emphasizing the value of structured physical activity and movement interventions for children's motor development. A 2024 meta-analysis of sports-game interventions involving children found overall benefits for fundamental motor skills, supporting the broader proposition that appropriately structured movement experiences can promote motor competence Sun & Chen (2024) doi:10.3390/children11020254). Similarly, a 2024 meta-analysis of structured and unstructured interventions found that organized movement experiences can improve fundamental motor skills, although intervention characteristics and outcomes varied across studies Chen et al. (2024)doi:10.3389/fpubh.2024.1345566).

Recent evidence also indicates that school-based physical education can be an important setting for promoting physical literacy and motor competence. A 2024 scoping review identified school-based interventions delivered during physical education as an important component of physical-literacy promotion Grauduszus et al. (2024)(doi:10.3389/fpubh.2024.1322075). The current study contributes to this evidence by demonstrating how a relatively simple equipment modification can be embedded within the normal instructional process rather than requiring a specialized intervention infrastructure.

Theoretical, Methodological, and Practical Implications

The findings provide preliminary support for a constraints-based interpretation of equipment modification in primary physical education. The theoretical contribution is not that rubber balls universally improve volleyball skills, but that changing the physical properties of the equipment may alter the interaction between the learner and the task. In the present context, the modified ball potentially reduced the difficulty of ball reception and contact sufficiently to enable more successful attempts. Successful attempts may, in turn, provide more opportunities for students to stabilize the movement sequence through repeated practice (French et al., 1991, p. 274; Iwatsuki & Regis, 2020, p. 908). This interpretation is compatible with the constraints-led view that learning emerges from the interaction between performer, task, and environmental constraints rather than solely from prescriptive repetition Renshaw et al. (2010).

The results therefore refine a simple "more practice produces better performance" explanation. The important pedagogical issue may be the quality and accessibility of the practice environment (Ericsson et al., 1993; Rees et al., 2016, p. 1048). When the task is appropriately scaled to learners' capabilities, practice may become sufficiently successful to support continued engagement while still requiring meaningful coordination and control (Correia et al., 2018, p. 129; Hacques et al., 2020, p. 1386).

Methodological implications

Methodologically, the study demonstrates the value of combining iterative action research with quantitative longitudinal measurement. Rather than evaluating only a single pre-test/post-test difference, the study tracked performance across pre-cycle, Cycle I, and Cycle II. This allowed the improvement trajectory to be examined and showed that the largest increase occurred between baseline and Cycle I, followed by additional improvement in Cycle II.

The use of both a categorical outcome and a continuous score also strengthened interpretation. The categorical outcome demonstrated whether students crossed the mastery threshold, whereas the continuous score captured changes among students regardless of whether they crossed that threshold. This distinction is important because educational success cannot always be adequately represented by a binary pass/fail classification.

Nevertheless, the methodological contribution should not be overstated. The repeated-measures statistical results demonstrate change within the participating classroom but cannot separate the effect of the rubber ball from other factors occurring simultaneously, including teacher feedback, repeated exposure, maturation, familiarity with the assessment, and the cumulative effect of physical education instruction (Reis et al., 2024, p. 86; Yani et al., 2026, p. 581).

Practical implications

The practical implication is that low-cost equipment modification may provide a feasible strategy for primary-school physical education teachers when standard equipment is difficult for children to control. This may be particularly relevant in schools where access to specialized equipment is limited. The intervention does not require sophisticated technology or extensive infrastructure. A teacher can potentially adjust the equipment before increasing task complexity. This principle is consistent with evidence that scaled equipment can improve children's interaction with sport tasks and can make skill performance more accessible to less-skilled learners Buszard et al. (2016).

However, the practical recommendation should be understood as progressive scaling rather than permanent simplification. If learners remain with an overly easy task, transfer to the standard volleyball environment may be limited. A more appropriate pedagogical sequence may therefore be:

Modified Equipment → Successful Movement Execution → Progressive Task Difficulty → Standard Volleyball → Game-Context Application.

This progression would preserve accessibility during early learning while eventually requiring students to adapt to the physical demands of authentic volleyball.

Strengths and Limitations

Several strengths should be acknowledged. First, the study was conducted in an authentic primary-school physical education environment, increasing its ecological relevance. Second, the intervention was implemented iteratively through two action cycles, allowing instructional refinement rather than relying solely on a single pre-post comparison. Third, all 34 students had complete outcome observations across the three assessment stages, eliminating participant-level missingness in the longitudinal analysis. Fourth, performance was assessed by two teacher-assessors who received a common briefing on the scoring criteria, reducing exclusive dependence on a single assessor.

The study also has important limitations: First, the single-group design without a comparator prevents strong causal inference. Improvements may reflect several concurrent influences, including repeated practice, teacher feedback, maturation, familiarity with the assessment, and the general progression of physical education instruction (Carl et al., 2022, p. 2993; Trouilloud et al., 2006, p. 96). The very large effect sizes should therefore not be interpreted as equivalent to treatment effects that would be expected from a randomized controlled trial. Second, the sample was derived from one intact Grade 4 class, limiting generalizability. The findings may not transfer directly to students of different ages, schools, socioeconomic conditions, skill levels, or cultural contexts. Replication across multiple schools and regions is required before broader claims can be made. Third, although two assessors were used and received a common briefing, the study did not report a formal quantitative inter-rater reliability coefficient. Both assessors were aware of the assessment stage, and no blinded video-based rescoring was performed. Consequently, assessor judgment and stage-related expectancy may have contributed to some measurement variability. Fourth, the study measured immediate performance across instructional cycles but did not include a retention or transfer assessment. This is particularly important because previous research on scaled equipment has emphasized the distinction between immediate performance improvement and durable motor-skill learning (Buszard et al., 2016). Future research should therefore determine whether the improvement remains after a period without structured practice and whether students can perform the skill effectively using a standard volleyball. Fifth, the study did not quantitatively measure potential mechanisms such as perceived difficulty, confidence, motivation, practice repetitions, movement variability, or cognitive load (French et al., 1991, p. 274; Slovák et al., 2023, p. 1041877). Consequently, the proposed explanation that rubber-ball practice facilitates successful movement through altered task constraints remains theoretically plausible rather than directly demonstrated. Finally, the absence of a control condition means that the findings cannot determine whether rubber-ball practice is superior to other pedagogical approaches, such as conventional volleyball practice, game-based learning, Teaching Games for Understanding, or other forms of modified-equipment instruction. Recent volleyball pedagogy research continues to investigate alternative approaches to developing underhand-passing competence, indicating that equipment modification should be evaluated as one component within a broader pedagogical system rather than as a universally superior method.

Future Research

Future research should move beyond single-classroom action research toward multisite and controlled longitudinal designs. A cluster-randomized or quasi-experimental design involving several primary schools could compare rubber-ball instruction with standard-volleyball instruction, another modified-ball condition, or a pedagogically different approach such as game-based learning. Future studies should also examine dose-response relationships, including the number of sessions, practice repetitions, lesson duration, and progression of task difficulty. Such information would help identify whether the observed improvement depends primarily on equipment modification or on the amount and structure of practice. A second priority is the investigation of mechanisms. Researchers should measure perceived task difficulty, confidence, motivation, successful-contact frequency, movement variability, and teacher feedback to determine why modified equipment may facilitate learning. The constraints-led perspective provides a useful theoretical framework for examining these mechanisms because it emphasizes the interaction between individual, task, and environmental constraints (Guignard et al., 2020, p. 955; Liu, 2023, p. 3). Third, future studies should include retention and transfer tests. Students should be reassessed after several weeks without intervention and should be tested using standard volleyball equipment and, ideally, within representative game situations (Benjaminse et al., 2017, p. 959; Fleddermann et al., 2019, p. 1608). This would distinguish temporary performance enhancement from durable learning and functional transfer. Fourth, replication should involve different populations and contexts, including students with lower initial motor competence, different age groups, mixed-sex classes, rural and urban schools, and schools with different levels of equipment availability. Such studies would establish whether the intervention is culturally and contextually transferable. Finally, implementation research should examine the feasibility and cost-effectiveness of modified-equipment strategies. A low-cost intervention has greater practical value if teachers can implement it consistently, safely, and without substantial additional resources. Future research should therefore combine effectiveness outcomes with implementation measures such as fidelity, acceptability, feasibility, teacher workload, and cost. Overall, the present findings support further investigation of developmentally appropriate equipment modification as one component of primary physical education pedagogy. The evidence should nevertheless be interpreted cautiously: the current study demonstrates a strong within-classroom improvement trajectory, but controlled, multisite, and longer-term research is required to determine the independent and transferable effect of rubber-ball-based instruction.

CONCLUSION

This classroom action research demonstrated a progressive improvement in Grade 4 students' volleyball underhand-passing performance following the implementation of rubber-ball-based learning activities. Across the three assessment stages, the mean performance score increased from 67.94 points at pre-cycle to 79.15 points in Cycle I and 83.56 points in Cycle II, while the proportion of students achieving the predefined mastery criterion (≥75 points) increased from 29.41% to 76.47% and 88.24%, respectively. The predefined classical-mastery criterion of 85% was therefore achieved at the end of Cycle II.

The findings provide evidence of substantial within-classroom improvement in both continuous underhand-passing performance and criterion-based mastery. The intervention offers a practical example of how developmentally appropriate, low-cost equipment modification can be incorporated into iterative primary physical education instruction. However, because the study used a single intact class without randomization or a comparator group, the findings should not be interpreted as definitive evidence that rubber-ball media independently caused the observed improvement. The international relevance of the findings therefore lies primarily in demonstrating a feasible classroom-based equipment-adaptation strategy that warrants further evaluation through controlled, multisite, and longer-term studies, including retention and transfer assessments using standard volleyball equipment.

DECLARATIONS

Ethical Approval

Ethical approval for the study was obtained from the Ethics Research Committee of STOK Bina Guna, under approval number STOK/Research/Skripsi-2775, dated 11 January 2026. The study was conducted in accordance with the ethical requirements established by the approving institution for research involving human participants. Permission to conduct the study was obtained from the participating elementary school before the research activities were initiated.

Consent for Publication

Individual written informed consent from parents or legal guardians was not documented in the available research records. The study was conducted under institutional ethical approval and authorization from the participating school. The students were informed about the learning activities and research procedures in language appropriate to their age.

The authors acknowledge that the absence of documented written parental or legal-guardian consent represents a limitation in the documentation of participant consent. No claim of written parental/guardian consent is made in this manuscript.

Consent for Publication

No identifiable individual photographs, videos, names, or individual case descriptions are included in this manuscript. The results are presented in aggregate form and do not contain information intended to identify individual students.Consequently, no separate consent for publication of identifiable participant information was required for the materials currently included in the manuscript.

Author Contributions (CRediT)

[AUTHOR INPUT REQUIRED: Confirm the actual contribution of the author(s). The manuscript should use the CRediT taxonomy only for roles genuinely performed: Conceptualization; Methodology; Validation; Formal analysis; Investigation; Resources; Data curation; Writing—original draft; Writing—review and editing; Visualization; Supervision; Project administration; Funding acquisition.]

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Conflict of Interest

The author(s) should disclose any financial or non-financial relationships that could reasonably be perceived as influencing the research, analysis, interpretation, or publication.

Data Availability

he anonymized dataset generated and analysed during the current study is available from the corresponding author on reasonable request, subject to applicable ethical and institutional restrictions.

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