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Improving forehand and backhand stroke learning outcomes in table tennis through the discovery learning method

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ABSTRACT

Mastery of forehand and backhand strokes is fundamental to student success in table tennis, yet conventional teacher-centered instruction in Indonesian junior high schools often leaves psychomotor learning outcomes below the Minimum Completeness Criterion (KKM), largely because students are rarely given the opportunity to construct stroke technique through guided exploration rather than rote demonstration. This classroom action research examined whether the Discovery Learning method could improve forehand and backhand stroke learning outcomes among 15 eighth-grade students (Class VIII B) at SMP Negeri 1 Kabila, Gorontalo, Indonesia. Using a two-cycle Kemmis and McTaggart design comprising planning, action, observation, and reflection, data were collected through practical skill tests, observation sheets, and documentation, and analyzed descriptively-quantitatively against the KKM. Results showed the mean backhand score rose from 56.81 (13.33% completeness) in Cycle I to 85.22 (100% completeness) in Cycle II, while the mean forehand score rose from 68.76 (33.33% completeness) to 86.42 (100% completeness), corresponding to normalized gains of 0.66 and 0.57, respectively. The novelty of this study lies in demonstrating that structured, teacher-scaffolded discovery cycles, rather than unassisted exploration, can rapidly close the completeness gap in a resource-limited junior high school setting. These findings confirm that Discovery Learning is an effective and replicable alternative for teaching table tennis stroke technique in physical education.

Keywords: Discovery Learning; table tennis; forehand stroke; backhand stroke; classroom action research

ABSTRAK (Bahasa Indonesia, 150–200 kata)

Penguasaan pukulan forehand dan backhand merupakan dasar keberhasilan siswa dalam permainan tenis meja, namun pembelajaran konvensional yang berpusat pada guru di sekolah menengah pertama di Indonesia sering kali membuat hasil belajar psikomotorik siswa berada di bawah Kriteria Ketuntasan Minimal (KKM), karena siswa jarang diberi kesempatan untuk membangun sendiri pemahaman teknik pukulan melalui eksplorasi terbimbing. Penelitian tindakan kelas ini bertujuan untuk mengetahui apakah metode Discovery Learning dapat meningkatkan hasil belajar pukulan forehand dan backhand pada 15 siswa kelas VIII B SMP Negeri 1 Kabila, Gorontalo. Penelitian menggunakan desain dua siklus model Kemmis dan McTaggart yang meliputi tahap perencanaan, pelaksanaan, observasi, dan refleksi. Data dikumpulkan melalui tes praktik, lembar observasi, dan dokumentasi, kemudian dianalisis secara deskriptif kuantitatif berdasarkan KKM. Hasil penelitian menunjukkan nilai rata-rata pukulan backhand meningkat dari 56,81 (ketuntasan 13,33%) pada siklus I menjadi 85,22 (ketuntasan 100%) pada siklus II, sedangkan nilai rata-rata pukulan forehand meningkat dari 68,76 (ketuntasan 33,33%) menjadi 86,42 (ketuntasan 100%), dengan gain ternormalisasi masing-masing sebesar 0,66 dan 0,57. Kebaruan penelitian ini terletak pada pembuktian bahwa siklus discovery learning yang terbimbing secara terstruktur mampu menutup kesenjangan ketuntasan secara cepat pada konteks sekolah dengan keterbatasan sumber daya. Temuan ini menegaskan bahwa Discovery Learning merupakan alternatif pembelajaran yang efektif dan dapat direplikasi untuk pembelajaran teknik pukulan tenis meja.

Kata Kunci: Discovery Learning; tenis meja; pukulan forehand; pukulan backhand; penelitian tindakan kelas

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INTRODUCTION

Learning outcomes are widely regarded as the most tangible indicator of the success of a physical education (PE) lesson, because they reflect the extent to which students have internalized the movement concepts that a lesson is designed to teach. Within Physical Education, Sport, and Health (PJOK) at the junior high school level, table tennis is one of the small-ball games prescribed by the Merdeka Curriculum, and forehand and backhand strokes constitute the two most fundamental techniques that determine a student's ability to rally, attack, and eventually compete (Sudrajat et al., 2023). Table tennis is attractive as an instructional medium because it requires only a table, net, paddles, and a light ball, is playable by students of any age or sex, and is characterized by short, intermittent bursts of movement that make only moderate physical demands on beginners (Biernat et al., 2018; Zagatto et al., 2018). Despite this accessibility, mastering the forehand and backhand strokes is technically demanding: it requires the coordinated control of grip, stance, footwork, and the stroke itself, and even small errors in paddle angle or timing translate into inconsistent ball placement (Logan et al., 2018; Stodden et al., 2008).

In practice, however, PJOK teachers frequently rely on teacher-centered demonstration, in which the teacher performs the stroke and students imitate it with minimal opportunity to test, fail, and self-correct. Preliminary observation at SMP Negeri 1 Kabila indicated that this pattern was associated with low psychomotor learning outcomes: prior to intervention, the majority of Class VIII B students were unable to reach the school's Minimum Completeness Criterion (Kriteria Ketuntasan Minimal, KKM) of 75 for either stroke, and many students appeared passive and hesitant during practice sessions. This pattern is consistent with a broader body of motivational research showing that instruction which affords students little autonomy or competence-supportive feedback tends to depress engagement and skill acquisition (Diloy-Peña et al., 2024; Ryan & Deci, 2020).

An alternative long advocated in the learning-theory literature is Discovery Learning, a constructivist approach originating in Bruner's account of learning through active exploration, in which students are guided to construct their own understanding of a concept or skill rather than receiving it in a fully worked-out form (Ozdem-Yilmaz & Bilican, 2020). Bruner's model, and its subsequent elaborations, positions the teacher as a facilitator who poses problems, asks guiding questions, and scaffolds students toward discovering the correct movement pattern for themselves (Nur Arsyad et al., 2024). Meta-analytic evidence on discovery-based instruction is more nuanced than the term "discovery learning" might suggest: unassisted, unguided discovery has repeatedly been shown to be less effective than direct instruction (Kirschner et al., 2006; Mayer, 2004), whereas enhanced or guided discovery, in which students receive feedback, worked examples, or scaffolded prompts while exploring, reliably outperforms other instructional modes (Alfieri et al., 2011). This distinction is central to the present study, because the Discovery Learning method implemented here was deliberately structured and teacher-scaffolded across two classroom action research cycles rather than left as open-ended, unassisted exploration.

A growing number of studies have reported positive effects of Discovery Learning across a range of subjects and psychomotor domains. In physical education specifically, Discovery Learning has been shown to enhance creative thinking during PE lessons (Ladjar et al., 2018), and comparable discovery-oriented and problem-based approaches have improved learning outcomes and student attitudes in general classroom settings (Guntoro, 2024; Panggabean et al., 2023). Related work on discovery-based instruction embedded in edutainment media and remedial teaching strategies has likewise reported gains in student motivation and completeness of learning outcomes (Anggraini et al., 2024; Perdana et al., 2024). At the same time, the broader motor-learning literature emphasizes that psychomotor skill acquisition depends heavily on the quality and timing of feedback students receive while practicing (Zhou et al., 2021) and on the progressive development of fundamental movement competence that underlies sport-specific techniques such as the table tennis stroke (Holfelder & Schott, 2014; Logan et al., 2018; Stodden et al., 2008). More recent innovations, such as virtual-reality-assisted table tennis training, have shown that structured, feedback-rich practice environments can meaningfully improve forehand and backhand performance among older students (Huang & Hongseanyatham, 2025), reinforcing the theoretical expectation that guided, exploratory practice is more effective than passive observation of a model.

Nevertheless, a clear gap remains in the existing literature. First, most empirical studies of Discovery Learning in Indonesian schools have examined academic subjects such as physics, chemistry, or general classroom instruction (Anggraini et al., 2024; Panggabean et al., 2023; Perdana et al., 2024) rather than psychomotor sport skills. Second, where sport-specific applications exist, they tend to concentrate on team-invasion games such as basketball and volleyball (Ladjar et al., 2018) or rely on costly technology such as virtual reality (Huang &

Hongseanyatham, 2025), which is impractical for many under-resourced Indonesian public junior high schools. Third, classroom action research on physical education pedagogy has been called for as a means of generating classroom-embedded, practitioner-relevant evidence (Casey & Goodyear, 2015), yet very few such studies have specifically paired Discovery Learning with the forehand-backhand stroke pair in table tennis while quantifying improvement against an explicit completeness criterion.

The present study addresses this gap and offers two points of novelty. First, it applies a structured, two-cycle classroom action research design in which Discovery Learning is delivered through teacher-guided exploration rather than unassisted discovery, directly responding to the caution raised in the instructional-design literature regarding minimally guided instruction (Kirschner et al., 2006). Second, in addition to reporting mean scores and completeness percentages as is conventional in Indonesian classroom action research, this study quantifies the magnitude of improvement using the normalized gain statistic (Hake, 1998), a metric rarely applied in physical education action research but well suited to comparing pretest-posttest improvement when a ceiling effect (a maximum possible score of 100) is present. Accordingly, this study aims to determine whether, and to what extent, the Discovery Learning method improves the learning outcomes of forehand and backhand strokes in table tennis among Class VIII B students of SMP Negeri 1 Kabila across two instructional cycles.

RESEARCH METHOD

This study employed a Classroom Action Research (Penelitian Tindakan Kelas) design following the Kemmis and McTaggart model, which is organized into recurring cycles, each consisting of four stages: planning, action, observation, and reflection. This design was chosen because the objective was not merely to describe the effect of an instructional method under controlled conditions, but to iteratively improve actual classroom practice until an explicit completeness criterion was met, which is the defining rationale of classroom action research in Indonesian PJOK pedagogy.

The research was conducted at SMP Negeri 1 Kabila, Bone Bolango Regency, Gorontalo Province, Indonesia. The subjects were all 15 students of Class VIII B, selected using a total sampling technique because the class constituted a single, intact instructional group and the intervention was implemented as regular curricular teaching rather than as an experiment requiring random assignment. The research was carried out across two cycles, with each cycle comprising two meetings of instruction followed by a practical skill assessment.

Data were collected using three complementary instruments. First, a practical skill test assessed each student's forehand and backhand stroke performance using a rubric covering four technical components consistent with standard table tennis pedagogy: grip (grip), ready stance (stance), footwork, and stroke execution (Heru Mardianto, 2021; Santi Nurdianti et al., 2018), with scores converted to a 0-100 scale and compared against the school's Minimum

Completeness Criterion (KKM) of 75. Second, a structured observation sheet was used by the class teacher and a collaborating observer to record student engagement, participation, and technical errors during each meeting. Third, documentation in the form of field notes and photographs was used to support triangulation of the quantitative test scores. The content validity of the skill-test rubric was established through expert judgment by two PJOK lecturers prior to use, and inter-rater consistency between the teacher and the observer was checked on a subsample of students in each cycle.

The research procedure followed the four stages of the Kemmis and McTaggart cycle. In the planning stage, the researcher and the class teacher prepared the lesson plan, Discovery Learning worksheets containing guiding questions (for example, prompting students to experiment with paddle angle to control ball direction rather than being shown the correct angle directly), and the practical assessment rubric. In the action stage, students were organized into small practice groups and given structured exploration tasks: rather than beginning with a full demonstration, the teacher posed a movement problem, allowed students to attempt and adjust their own stroke technique, and then provided corrective, competence-supportive feedback once patterns of error became apparent, consistent with recommendations that feedback should be timed to follow a period of active student exploration rather than precede it (Zhou et al., 2021). In the observation stage, the observer and teacher recorded student performance and behavioral indicators using the rubric and observation sheet described above. In the reflection stage, the research team reviewed the cycle's results against the KKM, identified the specific technical weaknesses that had limited student scores, and used these findings to refine the guiding questions, task difficulty, and grouping arrangement for the following cycle.

Data were analyzed using descriptive quantitative techniques appropriate to a two-cycle action research design with a small, intact class. For each cycle and each stroke (forehand and backhand), the mean score and the percentage of students achieving individual completeness (score ≥ 75) were calculated; the class was considered to have achieved classical completeness once at least 85% of students met the individual KKM, consistent with common Indonesian school assessment standards. To quantify the magnitude of improvement between Cycle I and Cycle II independently of the ceiling imposed by the 100-point scale, the normalized gain $\langle g \rangle$ was additionally computed following Hake (1998), defined as the ratio of the actual mean gain to the maximum possible mean gain (100 minus the Cycle I mean), with $\langle g \rangle \geq 0.7$ classified as high, $0.3 \leq \langle g \rangle < 0.7$ as medium, and $\langle g \rangle < 0.3$ as low.

RESULTS

Data were collected across two instructional cycles, each following the planning-action-observation-reflection sequence described above. The findings are presented separately for Cycle I and Cycle II, and for the backhand and forehand strokes, followed by the normalized-gain analysis quantifying the magnitude of improvement.

In Cycle I, students' initial exposure to the Discovery Learning tasks revealed considerable difficulty in coordinating grip, stance, and stroke execution. Observation notes indicated that most students focused on hitting the ball rather than controlling paddle angle and follow-through, resulting in inconsistent ball placement. The mean score for the backhand stroke in Cycle I was 56.81, with only 13.33% of students (2 of 15) reaching the KKM of 75. The mean score for the forehand stroke was somewhat higher, at 68.76, with 33.33% of students (5 of 15) reaching completeness. Reflection at the end of Cycle I attributed the low completeness rate primarily to insufficient guided practice time, unclear guiding questions in the discovery worksheets, and limited opportunities for students to receive individualized corrective feedback before the assessment.

These findings informed revisions implemented in Cycle II: guiding questions were made more specific and sequenced from simpler to more complex movement problems, practice groups were reduced in size to allow more frequent teacher feedback, and additional repetition drills targeting footwork and follow-through were incorporated between the exploration and assessment phases. In Cycle II, both stroke techniques showed marked improvement. The mean backhand score rose to 85.22, with 100% of students (15 of 15) reaching the KKM. The mean forehand score rose to 86.42, likewise with 100% completeness. Observation notes for Cycle II recorded higher student engagement, more purposeful experimentation with paddle angle, and greater willingness among students to self-correct after receiving feedback, consistent with the expected behavioral signature of guided rather than unassisted discovery.

Table 1. Data Analysis Results.

Stroke and Cycle	Mean Score	Completeness (%)	Normalized Gain ⟨g⟩	Category
Backhand – Cycle I	56.81	13.33%	–	–
Backhand – Cycle II	85.22	100.00%	0.66	Medium
Forehand – Cycle I	68.76	33.33%	–	–
Forehand – Cycle II	86.42	100.00%	0.57	Medium

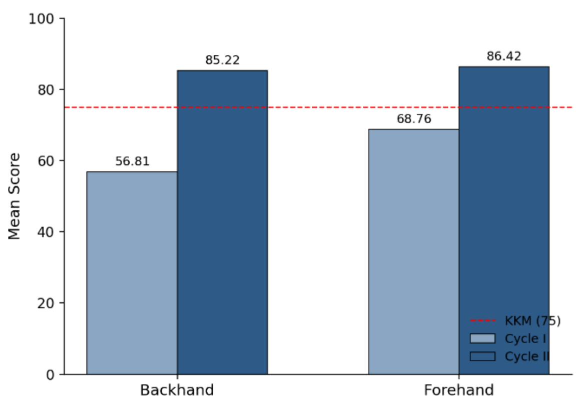

Figure 1. Comparison of Mean Backhand and Forehand Stroke Scores between Cycle I and Cycle II

Table 1 and Figure 1 summarize these findings. Across both strokes, the normalized gain fell within Hake's (1998) medium category ($0.3 \leq \langle g \rangle < 0.7$), with the backhand stroke ($\langle g \rangle = 0.66$) improving proportionally more than the forehand stroke ($\langle g \rangle = 0.57$). This pattern is consistent with the backhand having started from a lower baseline and therefore having greater room for improvement, while the forehand, already closer to completeness in Cycle I, improved by a smaller but still substantial margin. Taken together, the mean-score, completeness-percentage, and normalized-gain indicators converge on the same conclusion: two structured cycles of teacher-scaffolded Discovery Learning were sufficient to move the entire class from a state of majority non-completeness to full classical completeness (100% of students ≥ KKM) on both stroke techniques.

A closer breakdown of the practical skill rubric across its four technical components (grip, stance, footwork, and stroke execution) clarifies which aspects of performance drove the overall improvement. In Cycle I, observation notes indicated that grip and stance were relatively well executed by most students from the outset, since these are the most visually salient and most directly imitable components of the technique. Footwork and stroke execution, by contrast, were consistently the weakest components across both strokes in Cycle I, with students frequently remaining static instead of stepping into the stroke and mistiming the point of contact with the ball. These two sub-components accounted for the majority of point deductions on the Cycle I rubric and were therefore prioritized in the Cycle II revisions, through additional footwork ladders and slow-motion paired practice in which one student fed the ball while the partner focused solely on foot positioning before adding the stroke itself.

Behavioral data from the observation sheets reinforced the quantitative test results. In Cycle I, the observer recorded that fewer than half of the students voluntarily attempted a second or third variation of the stroke after an initial failed attempt, with most instead waiting for further teacher demonstration; several students also displayed visible hesitation, such as delaying their turn or repeatedly asking the teacher to confirm the correct paddle angle before attempting the stroke themselves. By Cycle II, the same observation sheet indicated that the great majority of students attempted multiple self-initiated variations of grip and footwork without prompting, and peer-to-peer correction, students pointing out footwork or timing errors to one another, emerged spontaneously during practice, a behavior that had not been recorded at all in Cycle I. Documentation photographs likewise showed a visible shift from students standing in a single fixed position awaiting instruction in Cycle I to students actively moving between the ready position and the point of contact in Cycle II, consistent with the footwork-focused revisions implemented between cycles.

DISCUSSION

The finding that both stroke techniques reached full classical completeness after two cycles of Discovery Learning is consistent with, and extends, prior evidence that structured discovery-oriented instruction improves psychomotor and cognitive learning outcomes more effectively than teacher-centered demonstration alone (Guntoro, 2024; Ladjar et al., 2018; Panggabean et al., 2023). Importantly, however, the magnitude and consistency of improvement observed here align more closely with the literature on enhanced or guided discovery than with unassisted, pure discovery. Alfieri et al. (2011) showed in a meta-analysis that discovery-based instruction is only effective when it includes feedback, scaffolding, or worked examples, while Kirschner et al. (2006) and Mayer (2004) both cautioned that minimally guided instruction tends to overload novice learners' working memory and produce weaker outcomes than direct instruction. The present study's design directly incorporated these cautions: the teacher posed guiding questions and problems but did not leave students entirely unassisted, instead providing corrective feedback once error patterns emerged, a sequencing consistent with recommendations in the motor-learning literature that feedback should follow, rather than precede, a period of active exploration (Zhou et al., 2021).

The improvement pattern also resonates with motivational theory. Self-determination theory holds that instructional conditions supporting autonomy and competence tend to sustain engagement and, in turn, skill development (Ryan & Deci, 2020), and empirical work in physical education has linked more autonomy-supportive, less controlling teaching styles to better student outcomes and lower disengagement (Abós et al., 2018; Diloy-Peña et al., 2024). The qualitative observation notes collected in this study, which recorded increased student initiative and willingness to self-correct in Cycle II, are consistent with this theoretical account: by allowing students to test and adjust their own stroke technique rather than simply copy a demonstration, the Discovery Learning method appears to have supported precisely the sense of autonomy and competence that self-determination theory identifies as central to sustained skill improvement.

From a motor-learning perspective, the results also underscore the importance of practising the specific technical sub-components of a skill rather than the skill as an undifferentiated whole. Both the backhand and forehand rubrics used in this study assessed grip, stance, footwork, and stroke execution separately, and the Cycle II revisions that specifically targeted footwork and follow-through were associated with the largest gains, echoing the broader literature on fundamental movement skill development, which emphasizes that sport-specific techniques are built upon a foundation of well-practised component movements (Holfelder & Schott, 2014; Logan et al., 2018; Stodden et al., 2008). This is also broadly consistent with reports that structured, feedback-rich practice environments, including technology-assisted ones such as virtual reality, can produce comparable forehand and backhand improvements in older students (Huang & Hongseanyatham, 2025); the present findings suggest that a similar improvement can be achieved without specialized equipment, using only conventional classroom resources supplemented by a well-designed discovery-learning procedure.

More broadly, these findings add to accumulating evidence, drawn largely from non-sport educational settings, that active, student-centered learning outperforms passive instruction (Freeman et al., 2014) and that cooperative, interdependent task structures can support both achievement and engagement among school-age learners (Bertucci et al., 2016). The present study extends this evidence into a psychomotor, sport-skill domain and into the specific context of a resource-limited Indonesian public junior high school, a setting in which few classroom action research studies have paired Discovery Learning with a specific, measurable sport skill such as the table tennis stroke (Casey & Goodyear, 2015).

Theoretically, this study reinforces the position that the effectiveness of "discovery learning" as a label is conditional on how it is implemented: the same underlying constructivist philosophy can produce either the weak, inconsistent results reported for unassisted discovery or the strong, consistent results reported here and elsewhere for guided, scaffolded discovery (Alfieri et al., 2011; Kirschner et al., 2006). Practically, the findings imply that PJOK teachers do not need costly technology to implement an effective Discovery Learning cycle for table tennis strokes; what appears to matter most is the structure of the cycle itself, specifically, clear guiding questions, small practice groups, timely corrective feedback, and iterative reflection between cycles that targets the specific technical weaknesses identified in the previous cycle.

CONCLUSION AND IMPLICATIONS

This study confirms that the Discovery Learning method, implemented through two structured, teacher-scaffolded classroom action research cycles, substantially improved forehand and backhand stroke learning outcomes among Class VIII B students at SMP Negeri 1 Kabila. Mean backhand scores rose from 56.81 to 85.22 and mean forehand scores rose from 68.76 to 86.42, with both strokes reaching 100% classical completeness by Cycle II and medium normalized gains ($\langle g \rangle = 0.66$ and 0.57, respectively). Theoretically, these findings reinforce the distinction between unassisted and guided discovery, showing that when exploration is combined with clear guiding questions and timely corrective feedback, Discovery Learning can be a highly effective pedagogy for psychomotor sport skills, not only for cognitive or academic content. Practically, the findings imply that PJOK teachers in resource-limited schools can adopt a similarly structured discovery-learning cycle, comprising guided exploration, targeted feedback, and iterative reflection, to raise table tennis stroke completeness without relying on costly equipment or technology.

RESEARCH LIMITATIONS

This study has several limitations that should be considered when interpreting its findings. The sample was limited to 15 students in a single class at one school, without a comparison or control group, which restricts the generalizability of the results to other classes, schools, or regions. As is typical of classroom action research, data analysis relied on descriptive statistics (means, completeness percentages, and normalized gain) rather than inferential hypothesis testing, so causal claims should be made cautiously. Skill assessment, although guided by a validated rubric and cross-checked by two raters, retains an element of observer judgment, and the two-cycle, four-meeting intervention period was relatively short, leaving the long-term retention of the improved stroke technique untested. Future research should consider a longer intervention with retention testing, a comparison group receiving conventional instruction, and replication across multiple classes or schools to strengthen the external validity of these findings.

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ETHICAL STATEMENT

This **article** has complied with the applicable **research ethics** standards involving human subjects as participants. All **research procedures** have obtained ethical approval from the **Research Ethics Committee** of Universitas Negeri Gorontalo with ethical approval certificate number: No. 074/UN47.B7/KEPK/2026. The **researchers** ensure the **confidentiality** of all participants' identities and have obtained **written informed consent** from each subject prior to data collection to ensure compliance with the **moral principles** in scientific research.

CONFLICT OF INTEREST

The **authors** hereby declare that there is no **conflict of interest** in the conduct of the **research** or in the preparation of this **article**, whether financial from any specific sponsor or non-financial with any party. All **data** presented in the **research results** are objective findings obtained in the field without any external intervention that could affect the **integrity** and **transparency** of this study. The **authors** take full responsibility for the **authenticity** and **validity** of the information provided in this **manuscript**.

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