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Discovery learning and motor ability effects on students' discus throw learning outcomes

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ABSTRACT

This study examined the effects of Discovery Learning and Conventional Learning, as well as their interaction with motor ability, on discus throw learning outcomes among eighth-grade students. A 2 × 2 factorial experimental design was conducted with 40 students from SMP Negeri 1 Pasaman. Participants were classified into high- and low-motor-ability groups and assigned to either Discovery Learning or Conventional Learning. Data were analyzed using descriptive statistics and two-way ANOVA ($\alpha = .05$). Discovery Learning significantly outperformed Conventional Learning ($F = 50.29$, $p < .001$). A significant interaction was found between learning model and motor ability ($F = 50.10$, $p = .048$). Students taught through Discovery Learning achieved higher mean scores than those receiving Conventional Learning in both high (13.37 vs. 11.58) and low (12.72 vs. 11.40) motor-ability groups. Discovery Learning is more effective than Conventional Learning for improving discus throw learning outcomes, and its effectiveness is influenced by students' motor ability.

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Introduction

Physical education plays a vital role in developing students' physical literacy, motor competence, confidence, and lifelong participation in physical activity. Previous intervention studies have shown that structured physical education programs improve motor skills and physical competence among children and adolescents (Hyacinthe et al., 2025; Megahed & Tarek, 2023). In secondary schools, discus throw is one of the most technically demanding athletic events because it requires the integration of grip, balance, body rotation, force production, release angle, and follow-through within a coordinated movement sequence. However, learning often relies on teacher demonstration and repetitive practice, limiting students' opportunities to understand movement principles and solve movement problems independently. Therefore, an instructional approach that actively engages students in learning is needed to improve discus throw performance.

Discovery Learning has been widely recognized as a learner-centered approach that promotes knowledge construction through guided exploration, questioning, experimentation, and reflection. In discus throw instruction, this model enables students to investigate how body position, balance, movement timing, force direction, and release mechanics influence throwing performance, while teachers provide guidance and feedback throughout the learning process (Raheem et al., 2024; Sahib & Abugneam, 2021; Sinulingga et al., 2021). Previous studies reported that guided discovery facilitates motor-skill acquisition when learning activities are

systematically structured (Abdul Ali Kazem, 2026; Leigh et al., 2010). Likewise, learner-centered physical education programs have been associated with improvements in motor competence, movement knowledge, motivation, and confidence (Dinu et al., 2010; Mastalerz et al., 2013). Nevertheless, empirical evidence regarding the effectiveness of Discovery Learning in teaching technically complex athletic skills such as discus throw remains limited.

Motor ability is another key factor influencing the acquisition of complex movement skills. It includes coordination, balance, agility, speed, and power, which support efficient movement execution and adaptation during learning. Students with higher motor ability generally demonstrate better movement control and faster skill acquisition than those with lower motor ability. Previous studies confirmed that motor competence is positively associated with physical fitness, movement proficiency, and sport performance (Aziz et al., 2023; Kato et al., 2026). Furthermore, biomechanical and intervention studies indicate that appropriate instructional strategies can improve movement quality and throwing performance, suggesting that motor ability may influence students' responses to different learning models (Alhumaid & Atta, 2022; Maryam et al., 2009; Hamid et al., 2025; Kailani et al., 2025; Seki et al., 2025).

Despite these findings, important research gaps remain. Previous studies have mainly examined Discovery Learning in relation to general motor skills, physical literacy, or team sports, whereas discus throw research has focused primarily on biomechanics, strength training, and coaching without considering differences in students' motor ability (Jonasson & Eriksson, 2026; Nwachukwu et al., 2024; Babbitt & Kipp, 2026; Judge & Garcia-Carrillo, 2026; Sánchez-Moreno et al., 2025). Moreover, systematic reviews have emphasized the need to account for individual learner characteristics when evaluating motor-learning interventions because motor-competence assessment remains inconsistent across studies (Hamid et al., 2025; Jasem et al., 2022). Consequently, evidence explaining how Discovery Learning interacts with motor ability in improving discus throw learning outcomes is still limited.

This study addresses these gaps by simultaneously examining the effects of learning model and motor ability using a 2 × 2 factorial experimental design. Its novelty lies in investigating not only the main effect of Discovery Learning but also the interaction between instructional model and motor ability in discus throw learning. By distinguishing students with high and low motor ability, this study provides a more comprehensive explanation of instructional effectiveness for different learner characteristics. Therefore, the study aimed to examine the effects of Discovery Learning and Conventional Learning on discus throw learning outcomes, determine the interaction between learning model and motor ability, and compare the effectiveness of both learning models across different levels of motor ability. It was hypothesized that Discovery Learning would produce superior learning outcomes and that its effectiveness would vary according to students' motor ability.

Method

This study employed a 2 × 2 factorial experimental design to examine the effects of learning model and motor ability on discus throw learning outcomes among eighth-grade students. The study was conducted at SMP Negeri 1 Pasaman, West Pasaman Regency, Indonesia, from April to June 2026. The population consisted of 90 eighth-grade students enrolled in the 2025/2026 academic year. Using purposive sampling, 40 students who met the inclusion criteria actively participating in physical education classes, having no physical impairments, and possessing basic knowledge of discus throw techniques were selected. Motor ability was assessed using the Barrow Motor Ability Test, and participants were classified into high- and low-motor-ability groups based on the median test score. Within each motor-ability category, students were randomly assigned to either the Discovery Learning or Conventional Learning group, resulting in four experimental groups of equal size.

The intervention was implemented over eight instructional sessions during four weeks. Discovery Learning emphasized guided exploration, problem-solving, experimentation, teacher feedback, and reflective evaluation to encourage students to discover effective throwing techniques independently. In contrast, Conventional Learning focused on teacher explanation, demonstration, repetitive practice, and corrective feedback. Discus throw learning outcomes were assessed using the standardized Indonesian Athletics Association (PASI) performance test, in which each student performed three legal throws and the farthest distance was recorded as the final score. The Barrow Motor Ability Test demonstrated acceptable validity (0.723–0.761) and reliability (0.791–0.928). Before hypothesis testing, the data were examined for normality using the Shapiro–Wilk test and homogeneity using Levene's Test. The hypotheses were subsequently tested using a two-way analysis of variance (Two-Way ANOVA) at a significance level of 0.05. When a significant interaction was identified, simple-effect comparisons were conducted to examine differences between learning models within each motor-ability group. All statistical analyses were performed using IBM SPSS Statistics.

Results and Discussions

This study investigated the effects of learning model and motor ability on students' discus throw learning outcomes using a 2 × 2 factorial experimental design. The results are presented sequentially to provide a comprehensive overview of the data analysis. First, descriptive statistics summarize the pretest and posttest performance of each experimental group. Second, the distribution of students across performance categories is presented to illustrate changes in learning achievement. Third, the assumptions underlying the parametric analysis, including tests of normality and homogeneity of variance, are examined. Finally, the hypotheses are tested using a two-way analysis of variance (Two-Way ANOVA), followed by comparisons between learning models at different levels of motor ability to determine the effectiveness of Discovery Learning relative to conventional instruction in improving discus throw learning outcomes.

Table 1. Descriptive Statistics of Discus Throw Learning Outcomes

Learning model	Motor ability	Test	n	Minimum	Maximum	Mean	SD
Discovery learning	High	Pretest	10	11.03	14.79	13.37	1.30
Discovery learning	High	Posttest	10	12.20	15.25	14.07	1.07
Discovery learning	Low	Pretest	10	11.78	15.35	14.21	1.23
Discovery learning	Low	Posttest	10	12.40	15.70	14.67	1.27
Conventional learning	High	Pretest	10	10.25	11.73†	12.85†	1.70
Conventional learning	High	Posttest	10	10.26	15.30	12.77	1.65
Conventional learning	Low	Pretest	10	10.33	13.65	12.39	1.02
Conventional learning	Low	Posttest	10	12.38†	13.67	12.43	1.00

Table 1 shows that the discovery-learning groups demonstrated higher posttest scores than the conventional-learning groups. Among students taught through discovery learning, the mean score increased from 13.37 to 14.07 in the high-motor-ability group and from 14.21 to 14.67 in the low-motor-ability group. In comparison, the conventional-learning groups obtained posttest means of 12.77 and 12.43 for students with high and low motor ability, respectively. These descriptive patterns suggest that discovery learning was associated with better discus-throw learning outcomes across both motor-ability categories. However, several numerical inconsistencies in the conventional-learning data should be checked against the original SPSS dataset before publication.

Table 2. Distribution of Students Across Performance Categories

Learning model	Motor ability	Test	Very good, n (%)	Good, n (%)	Moderate, n (%)	Poor, n (%)	Very poor, n (%)
Discovery learning	High	Pretest	0 (0)	4 (40)	3 (30)	2 (20)	1 (10)
Discovery learning	High	Posttest	0 (0)	5 (50)	2 (20)	1 (10)	2 (20)
Discovery learning	Low	Pretest	0 (0)	4 (40)	3 (30)	2 (20)	1 (10)
Discovery learning	Low	Posttest	0 (0)	5 (50)	2 (20)	2 (20)	1 (10)
Conventional learning	High	Pretest	0 (0)	3 (30)	3 (30)	3 (30)	1 (10)
Conventional learning	High	Posttest	0 (0)	3 (30)	3 (30)	3 (30)	1 (10)
Conventional learning	Low	Pretest	0 (0)	4 (40)	3 (30)	2 (20)	1 (10)
Conventional learning	Low	Posttest	0 (0)	3 (30)	3 (30)	3 (30)	1 (10)

The categorical distributions indicate that discovery learning produced a larger concentration of students in the good-performance category at posttest. In both motor-ability groups, 50% of students receiving discovery learning were classified as good, compared with 30% of students in the corresponding conventional-learning groups. No student was categorized as very good in any group. Although some students remained in the poor or very poor categories, the overall posttest distribution favored discovery learning, particularly through the greater proportion of students attaining the good category.

Table 3. Summary of Normality and Homogeneity Tests

Statistical assumption	Group or test	n	Reported statistic	p value	Reported decision
Normality	Discovery learning	20	Not reported	.001†	Normal
Normality	Conventional learning	20	Not reported	.001†	Normal
Normality	High motor ability	20	Not reported	.001†	Normal
Normality	Low motor ability	20	Not reported	.001†	Normal
Homogeneity of variance	Levene's test	40	Not reported	.167	Homogeneous

Levene's test produced a significance value of .167, which exceeded the .05 threshold and therefore supported the assumption of equal error variances across the four experimental groups. However, the reported normality results were inconsistent with the stated decision criterion. All groups were reported to have p = .001 but were nevertheless classified as normally distributed. Because p = .001 is below .05, these results should not be presented as evidence of normality without checking the test type, statistical output, and whether the values reported were test statistics rather than significance probabilities. Thus, the homogeneity assumption was supported, whereas the normality assumption requires confirmation before the two-way ANOVA results are submitted for publication.

Table 4. Two-Way ANOVA of Discus Throw Learning Outcomes

Source of variation	F	p value	Decision	Interpretation
Learning model	50.29	< .001	Reject H_0	Significant main effect
Motor ability	Not reported	Not reported		Cannot be evaluated
Learning model × motor ability	50.10	.0483	Reject H_0	Significant interaction

The two-way ANOVA indicated a significant main effect of learning model on discus-throw learning outcomes, F = 50.29, p < .001. This finding demonstrates that students' performance differed according to whether they were taught through discovery learning or conventional instruction. A statistically significant interaction was also reported between learning model and motor ability, F = 50.10, p = .0483, indicating that the effectiveness of the instructional model varied according to students' motor-ability level. Nevertheless, a complete journal-standard ANOVA table should additionally report degrees of freedom, sums of squares, mean squares, partial eta squared, and the main effect of motor ability.

To provide a clearer interpretation of the interaction between learning model and motor ability, the mean discus throw learning outcomes for each experimental group are presented in Figure 1. The interaction plot illustrates the performance differences between students taught using Discovery Learning and Conventional Learning across high and low motor-ability groups, thereby facilitating visualization of the interaction effect identified by the two-way ANOVA.

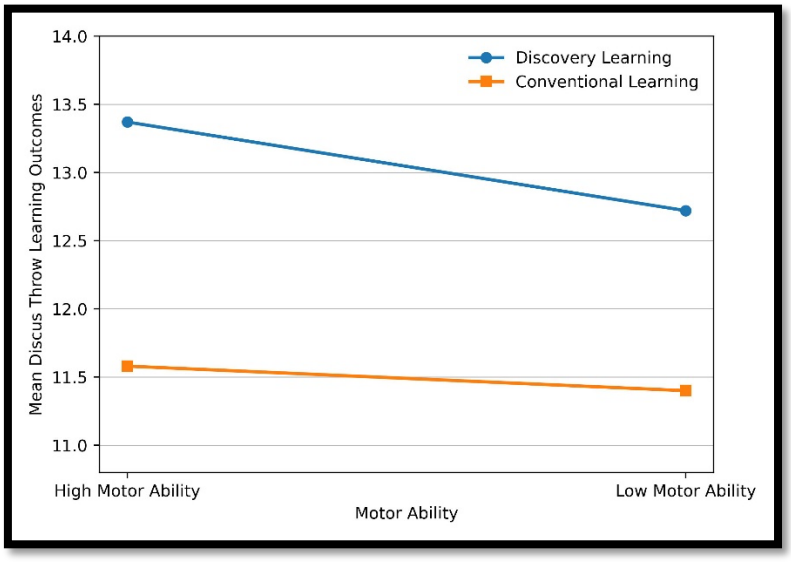

Figure 1. Interaction Plot of Learning Model and Motor Ability on Discus Throw Learning Outcomes

Table 5. Comparisons Between Learning Models at Each Motor-Ability Level

Motor-ability level	Discovery learning, Mean	Conventional learning, Mean	Mean difference	Superior model	Statistical significance
High motor ability	13.37	11.58	1.79	Discovery learning	Reported as significant
Low motor ability	12.72	11.40	1.32	Discovery learning	Reported as significant

Among students with high motor ability, those taught through discovery learning obtained a mean score of 13.37, compared with 11.58 for those receiving conventional instruction, resulting in a mean difference of 1.79 points. A similar pattern emerged among students with low motor ability, for whom discovery learning produced a mean score of 12.72, compared with 11.40 under conventional instruction, corresponding to a difference of 1.32 points. These comparisons indicate that discovery learning outperformed conventional instruction at both motor-ability levels, with a somewhat larger advantage among students with high motor ability. However, the source did not report the test statistics, standard errors, confidence intervals, or adjusted p values for these simple-effect comparisons.

The present study demonstrated that Discovery Learning was more effective than Conventional Learning in improving students' discus throw learning outcomes. Beyond its statistical significance, this finding indicates that learner-centered instruction enables students to understand the biomechanical principles of discus throwing through active exploration, movement evaluation, and problem-solving rather than passive imitation. Consequently, students in both high- and low-motor-ability groups achieved higher learning outcomes and a greater proportion reached the good-performance category than those taught conventionally. These findings support the view that active cognitive engagement facilitates more effective motor learning and skill acquisition in physical education (Shilaskar et al., 2024; K. Zhao et al., 2023).

The superiority of Discovery Learning can be attributed to the complex nature of discus throwing, which requires the coordinated integration of balance, body rotation, timing, force production, and release mechanics. Guided exploration allows students to evaluate movement errors, modify throwing strategies, and refine technical execution through continuous practice and teacher feedback. This process strengthens both conceptual understanding and movement performance because learners actively construct knowledge from experience. Similar findings have shown that guided discovery enhances long-term motor learning, adaptive decision-making, and technical skill development in sport (Sánchez-Moreno et al., 2025; Babbitt & Kipp, 2026; Y. Zhao & Zhao, 2023).

Another important finding was the significant interaction between learning model and motor ability, indicating that instructional effectiveness depends partly on students' motor competence. Students with higher motor ability generally possess better coordination, balance, movement efficiency, and body control, enabling them to benefit more from exploratory learning activities. Nevertheless, students with lower motor ability also showed better performance under Discovery Learning because structured guidance and continuous feedback supported gradual improvement in movement quality. These findings extend previous evidence that motor competence is associated with physical fitness and sport-specific skill acquisition by demonstrating its moderating role in learner-centered physical education (Arjona & Espinel, 2023; Seki et al., 2025).

Discovery Learning produced greater improvements among students with high motor ability while remaining beneficial for those with lower motor ability. Students with stronger motor competence were better able to process movement feedback and optimize technical adjustments during practice, whereas students with lower competence benefited from progressively structured learning tasks and teacher scaffolding. These findings are consistent with previous studies showing that motor competence facilitates complex skill acquisition and that appropriate instructional support enhances learning among less-skilled students (Henjilito et al., 2026; Kailani et al., 2025; Aleixo et al., 2026; Judge & Garcia-Carrillo, 2026). Therefore, effective implementation of Discovery Learning requires teachers to adjust task complexity, feedback, and learning support according to students' motor characteristics.

This study contributes to learner-centered physical education research by demonstrating that motor ability moderates the effectiveness of Discovery Learning in teaching discus throwing. However, the relatively small sample from a single school and the interaction effect close to the significance threshold limit the generalizability of the findings. Future studies should include larger multicenter samples, report standardized effect sizes, incorporate retention and transfer tests, and examine biomechanical variables to clarify the mechanisms through which Discovery Learning improves discus throw performance across different levels of motor ability.

Conclusions

This study concludes that Discovery Learning is more effective than Conventional Learning in improving discus throw learning outcomes among eighth-grade students. The learning model produced a significant main effect, and its effectiveness interacted significantly with students' motor ability. Students with both high and low motor ability achieved better performance through Discovery Learning than through Conventional Learning, with a greater mean advantage observed in the high-motor-ability group. These findings indicate that discus throw instruction should not rely solely on teacher-centered demonstration and repetition, but should incorporate guided exploration, problem-solving, and active movement practice. Therefore, physical education teachers are encouraged to implement Discovery Learning while adapting task difficulty, feedback, and instructional support to students' motor-ability levels.

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