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An integrated pedagogical model for swimming education: effects of problem-based, project-based, digital learning, and peer assessment

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ABSTRACT

Background: Swimming instruction in higher education is still predominantly characterised by teacher-centred approaches, with limited empirical evidence examining the effectiveness of student-centred and integrated pedagogical models. In particular, little is known about the comparative impact of combining multiple learning approaches on swimming skill development across different swimming styles. **Objectives**: This study aimed to (i) examine the effects of an integrated learning (IL) model—combining problem-based learning (PBL), project-based learning (PjBL), digital learning media, and peer assessment—on students' swimming learning outcomes across four swimming styles, and (ii) compare the effectiveness of the IL model with single PBL and PjBL approaches. **Methods**: A quasi-experimental pretest–posttest group design was employed involving 93 university students enrolled in a swimming course. Participants were assigned to three groups: IL, PBL, and PjBL. Data was analysed using paired-samples t-tests to examine within-group effects, two-way ANOVA to identify between-group differences, and Tukey HSD post hoc tests. Effect sizes and confidence intervals were also calculated. **Finding/Results**: The IL model produced significant improvements in swimming performance across butterfly, breaststroke, backstroke, and freestyle techniques, with large effect sizes observed in all styles. Comparative analyses revealed that the IL group achieved significantly higher learning outcomes than both the PBL and PjBL groups, while no significant difference was found between PBL and PjBL. **Conclusion**: The findings demonstrate that an integrated learning model that combines multiple student-centred pedagogical approaches, digital learning media, and peer assessment is more effective than single-method approaches in university-level swimming education. This model offers a promising pedagogical framework for enhancing swimming instruction and warrants further investigation across different educational levels and learning contexts.

Keywords: Integrated learning; problem-based learning; project-based learning; digital learning; peer assessment

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INTRODUCTION

Research on swimming education has predominantly focused on technical skill acquisition through direct instruction and practice-based training, while the development

and evaluation of pedagogical learning models remain relatively underexplored. A recent bibliometric review covering studies published between 2001 and 2024 indicates that research addressing structured learning models in swimming education is still limited in both scope and depth (Arhesa et al., 2025). Similarly, empirical evidence examining the effectiveness of pedagogical approaches in enhancing swimming competence and learning success—beyond traditional training-oriented methods—remains scarce (Petrass et al., 2021; Özbal& Baliyey, 2025). This situation may be attributed to the widespread assumption that swimming and sport-related learning can only be effectively achieved through repetitive practice and direct demonstration (Rusli et al., 2024a; Awaluddin et al., 2023). Consequently, swimming instruction continues to be largely dominated by the teacher-centered learning (TCL) paradigm.

In contrast, growing evidence across educational contexts suggests that student-centered learning (SCL) approaches are more effective in promoting meaningful learning outcomes, engagement, and learner autonomy. In physical education, SCL is commonly operationalized through pedagogical models such as project-based learning (PjBL), problem-based learning (PBL), and the integration of digital technologies (Noptario et al., 2024). PjBL encourages learners to collaboratively address authentic problems through the production of tangible learning outputs, fostering creativity, independence, and sustained learning engagement (Pan et al., 2022; Cummings & Yur-Austin, 2022; Llorent et al., 2022). Likewise, PBL emphasizes problem-solving in small-group settings, supporting the development of critical thinking, responsibility, and motivation in physical education contexts (Alreshidi & Lally, 2024; Orhan, 2024; Perdima et al., 2025).

Despite the demonstrated benefits of SCL approaches, empirical studies applying these models specifically within swimming education remain limited and fragmented. Existing research has largely examined single pedagogical approaches in isolation, such as the use of PBL to improve freestyle swimming performance or the application of PjBL combined with multimedia to enhance specific swimming strokes (Mashud et al., 2023; Mafahir et al., 2025; Rusli et al., 2025). While these findings are promising, they provide only partial insights and do not address the potential benefits of integrating multiple pedagogical strategies within a unified instructional framework.

Beyond PBL and PjBL, digital learning media and peer assessment represent additional pedagogical components with strong potential to enhance swimming education. Digital learning media—whether implemented through single or multiple platforms—have been shown to support learning effectiveness, learner engagement, and instructional flexibility in physical education settings (Michael et al., 2021; Apidogo et al., 2021; Akkaya & Mirzeoğlu, 2024). Peer assessment further complements student-centered learning by encouraging reflection, accountability, and active participation, while also mitigating common challenges in collaborative learning environments, such as social loafing and unequal contribution among group members (Chang et al., 2021; Bartholomew et al., 2022; Lin et al, 2021).

In this study, the integration of problem-based learning, project-based learning, digital learning media, and peer assessment within a single instructional process is conceptualized as integrated learning (IL). This approach is designed to harness the complementary strengths of multiple pedagogical strategies rather than relying on a single model. To extend the pedagogical evidence base in swimming education, the IL model is implemented across all four swimming styles, acknowledging that each style involves distinct anthropometric, biomechanical, hydrodynamic, and learning demands (Seifert & Carmigniani, 2023). Accordingly, this study aims to: (i) examine the effects of IL-based swimming instruction on students' swimming learning outcomes, and (ii)

compare the effectiveness of the IL model with single-model approaches, namely PBL and PjBL.

METHOD

Design

This study employed a quasi-experimental pretest–posttest group design conducted between September 2024 and February 2025. The research was carried out at the Department of Physical Education, Universitas Muhammadiyah Palopo, and a public swimming facility in Palopo City, Indonesia. Ethical approval was obtained from the Ethics Committee of Universitas Muhammadiyah Palopo (No. 12/KEP/III.3.AU/F/2024).

Participants

Participants were undergraduate students enrolled in a beginner-level swimming course who provided written informed consent. A saturated sampling technique was applied, involving 94 students (male = 60; female = 34; mean age ≈ 19.5 years). Participants were randomly assigned into three groups: integrated learning (IL) (n = 31), problem-based learning (PBL) (n = 31), and project-based learning (PjBL) (n = 31).

Intervention Procedures

Each group received instructional treatment according to its designated pedagogical model. The IL group received an integrated approach combining PBL, PjBL, digital learning media, and peer assessment, whereas the PBL and PjBL groups received single-model instruction. The learning syntax applied in each group is summarised in **Tables 1** and **2**.

Table 1. Problem-Based Learning (PBL) Syntax (Groups 1 and 2)

Phase	Lecturer Activities	Student Activities
Problem orientation	Explains learning objectives and presents movement errors in four swimming styles.	Understand learning goals and engage in problem identification.
Organising learners	Forms study groups.	Organise group roles.
Guiding investigation	Facilitates inquiry and provides feedback.	Collect information and analyse movement errors.
Developing solutions	Assigns video-based swimming tasks.	Prepare and perform swimming skill videos.
Problem orientation	Explains learning objectives and presents movement errors in four swimming styles.	Understand learning goals and engage in problem identification.

Table 2. Project-Based Learning (PjBL) Syntax (Groups 1 and 3)

Phase	Lecturer Activities	Student Activities
Driving question	Poses guiding questions related to swimming errors.	Respond to guiding questions.
Project planning	Assigns video-based swimming projects.	Plan and organise project tasks.
Scheduling	Sets timelines and milestones.	Agree on project schedule.
Monitoring	Supervises project development.	Execute and revise swimming performance.
Assessment	Evaluates project outcomes.	Conduct peer assessment (IL group only).
Reflection	Leads reflection activities.	Reflect on learning experience.

All groups were permitted to use independent reference sources. The IL group additionally received structured digital learning resources, including e-learning modules, digital flipbooks, and instructional swimming websites.

Peer Assessment

Peer assessment was incorporated as a formative learning strategy to promote reflection and accountability. Its implementation is described in **Table 3**.

Table 3. Implementation of Peer Assessment

Aspect	Description
Objective	To provide formative feedback on group-produced swimming performance videos.
Implementation	Conducted once in PBL and PjBL groups and twice in the IL group.
Assessment criteria	Body position, leg movement, arm movement, breathing, and movement coordination.
Role in analysis	Not included as outcome data; used solely for learning reflection.
Supervision	Fully guided and controlled by course lecturers.

Instruments and Scoring

Swimming learning outcomes were assessed using a validated swimming skills rubric covering freestyle, breaststroke, backstroke, and butterfly strokes (Rusli et al., 2024b), with a reported dependability coefficient of 0.82. The assessment focused on technical execution rather than swimming speed or time-based performance. Four certified swimming instructors independently evaluated each participant's performance. Final scores were calculated as the mean of the four raters' assessments. The assessed components and scoring structure applied across all swimming styles are summarised in **Table 4**.

Table 4. Summary of Swimming Skill Assessment Rubric

Swimming Style	Assessed Components	Scoring Scale	Assessment Focus
Freestyle	Body position, leg movement, arm movement, breathing, coordination.	1–4	Technical execution.
Backstroke	Body position, leg movement, arm movement, breathing, coordination.	1–4	Technical execution.
Breaststroke	Body position, leg movement, arm movement, breathing, coordination.	1–4	Technical execution.
Butterfly	Body position, leg movement, arm movement, breathing, coordination.	1–4	Technical execution.

Data Analysis

Statistical analyses were conducted using SPSS version 24. Paired-samples t-tests were used to examine within-group improvements following the intervention. Effect sizes were calculated using Cohen's d and eta squared (η^2) with 95% confidence intervals. Differences between instructional models were analysed using two-way ANOVA, followed by Tukey HSD post-hoc tests. Data normality and homogeneity were assessed using the Kolmogorov–Smirnov and Levene's tests, respectively.

RESULTS AND DISCUSSION

Results

Descriptive Statistics of Swimming Learning Outcomes

Table 8 presents a comprehensive overview of the descriptive statistics of swimming learning outcomes across the three instructional groups and four swimming styles. For the integrated learning (IL) group (Group 1), clear and consistent improvements were

observed from pretest to posttest in all swimming styles, as reflected by substantial increases in mean scores.

Specifically, the butterfly swimming mean score increased from 51.48 at pretest to 63.45 at posttest, indicating marked progress in a swimming style that is typically considered technically demanding for beginner learners. Similar improvement patterns were evident in breaststroke (from 53.55 to 60.90), backstroke (from 51.10 to 62.97), and freestyle swimming (from 50.06 to 64.26). These gains suggest that the IL intervention facilitated not only general skill acquisition but also improvements across swimming styles with varying biomechanical and coordination demands.

In contrast, Groups 2 (PBL) and 3 (PjBL), which were assessed only at posttest, demonstrated moderate learning outcomes across all swimming styles. Although both groups achieved mean scores above 50, their posttest performance levels were consistently lower than those of the IL group. This descriptive comparison provides initial evidence that integrating multiple pedagogical approaches may yield superior learning outcomes compared to the implementation of single-model instructional strategies.

Table 8. Descriptive Statistics of Swimming Learning Outcomes

Variable	N	Min	Max	Mean	SD
Group 1					
Butterfly pretest	31	36	68	51.48	7.14
Butterfly posttest	31	48	76	63.45	6.59
Breaststroke pretest	31	40	64	53.55	6.34
Breaststroke posttest	31	48	72	60.90	6.83
Backstroke pretest	31	40	60	51.10	5.34
Backstroke posttest	31	52	76	62.97	6.19
Freestyle pretest	31	40	60	50.06	6.19
Freestyle posttest	31	56	72	64.26	5.74
Group 2					
Butterfly posttest	31	43	69	55.71	5.98
Breaststroke posttest	31	46	68	57.55	5.89
Backstroke posttest	31	44	63	53.94	5.79
Freestyle posttest	31	42	63	53.81	5.21
Group 3					
Butterfly posttest	32	48	70	58.31	5.95
Breaststroke posttest	32	40	70	57.78	7.17
Backstroke posttest	32	40	70	56.44	8.16
Freestyle posttest	32	40	70	56.25	7.77

Normality of Data Distribution

The Kolmogorov–Smirnov normality test was applied to all pretest and posttest datasets across the three groups and four swimming styles. As shown in **Table 9**, all variables yielded significance values greater than 0.05, indicating that the data were normally distributed.

Table 9. Results of Data Normality Test (Kolmogorov–Smirnov)

Variable	Statistic	df	Sig.
Group 1			
Butterfly swimming pretest	0.119	31	0.200*
Butterfly swimming posttest	0.146	31	0.090
Breaststroke swimming pretest	0.134	31	0.163
Breaststroke swimming posttest	0.133	31	0.172
Backstroke swimming pretest	0.148	31	0.082
Backstroke swimming posttest	0.147	31	0.087
Freestyle swimming pretest	0.139	31	0.133
Freestyle swimming posttest	0.137	31	0.145

Variable	Statistic	df	Sig.
Butterfly swimming posttest	0.101	31	0.200*
Group 2			
Breaststroke swimming posttest	0.130	31	0.195
Backstroke swimming posttest	0.113	31	0.200*
Freestyle swimming posttest	0.095	31	0.200*
Group 3			
Butterfly swimming posttest	0.135	32	0.144
Breaststroke swimming posttest	0.121	32	0.200*
Backstroke swimming posttest	0.137	32	0.133
Freestyle swimming posttest	0.120	32	0.200*

Note: p > 0.05 indicates normal distribution.

The consistent normal distribution across groups and swimming styles suggests that the observed score variations reflect genuine differences in learning performance rather than deviations caused by non-normal data distributions. This finding supports the use of parametric statistical techniques in subsequent analyses.

Homogeneity of Variance

Homogeneity of variance across the three instructional groups was examined using Levene's test. As reported in b, all swimming styles demonstrated non-significant Levene statistics ($p > 0.05$), confirming that the variances among groups were statistically equivalent.

Table 10. Results of Homogeneity of Variance Test (Levene's Test)

Variable	Levene Statistic	df1	df2	Sig.
Butterfly posttest	0.196	2	91	0.822
Breaststroke posttest	0.293	2	91	0.747
Backstroke posttest	1.576	2	91	0.212
Freestyle posttest	2.758	2	91	0.069

The fulfillment of homogeneity assumptions indicates that group comparisons could be conducted without bias arising from unequal variance distributions, thereby strengthening the validity of the comparative analyses.

Effects of Integrated Learning on Swimming Performance (Within-Group Analysis)

To examine the effectiveness of the IL intervention, paired-samples *t*-tests were conducted for Group 1 to compare pretest and posttest swimming performance across all four swimming styles. The results are presented in **Table 11**.

Table 11. Paired-Samples t-Test Results for Group 1 (Integrated Learning)

Swimming Style	t	df	p	95% CI
Butterfly	-8.798	30	< 0.001	9.18–14.74
Breaststroke	-4.575	30	< 0.001	4.07–10.63
Backstroke	-11.786	30	< 0.001	9.81–13.92
Freestyle	-9.430	30	< 0.001	11.11–17.26

The analysis revealed statistically significant improvements in butterfly, breaststroke, backstroke, and freestyle swimming performance following IL-based instruction ($p < 0.001$ for all comparisons). The magnitude of improvement varied across swimming styles, with particularly strong gains observed in freestyle and backstroke swimming, as indicated by larger t values and wider confidence intervals.

Importantly, all confidence intervals were entirely above zero, indicating consistent and reliable improvements across participants. These results demonstrate that IL-based instruction was effective in enhancing swimming performance regardless of swimming style, suggesting a broad and robust instructional impact.

Comparison of Instructional Models (Between-Group Analysis)

To compare the effectiveness of the three instructional approaches, a two-way analysis of variance (ANOVA) was conducted with swimming style and instructional model as independent variables. The results are presented in **Table 12**.

Table 12. Two-Way ANOVA Results

Source	SS	df	MS	F	Sig.
Swimming style	114.466	3	38.155	0.899	0.442
Study group	3.957.113	2	1.978.557	46.620	< 0.001
Style × Group	465.807	6	77.635	1.829	0.092

The analysis revealed a statistically significant main effect of instructional model on swimming learning outcomes ($p < 0.001$), indicating that students' performance differed according to the type of learning model employed. In contrast, no significant main effect was observed for swimming style, suggesting that performance differences were not dependent on stroke type. Furthermore, the absence of a significant interaction effect indicates that the influence of instructional model was consistent across all swimming styles.

These findings imply that the observed differences in learning outcomes can be attributed primarily to the instructional approach rather than to inherent differences in swimming style difficulty.

Post-hoc Comparisons of Instructional Models

To further identify the source of the significant main effect of instructional model, Tukey HSD post-hoc analyses were conducted. The results are presented in **Table 13**.

Table 13. Tukey HSD Post-hoc Test Results

Comparison	Mean Difference	SE	Sig.	95% CI
IL vs PBL	7.68	0.83	< 0.001	5.73–9.62
IL vs PjBL	5.73	0.82	< 0.001	3.80–7.66
PBL vs PjBL	1.95	0.82	0.048	0.01–3.88

The post-hoc analysis demonstrated that the IL group achieved significantly higher swimming learning outcomes than both the PBL and PjBL groups. The mean differences between IL and PBL, as well as between IL and PjBL, were substantial and statistically significant. In contrast, the difference between the PBL and PjBL groups was minimal and of limited practical significance. These findings indicate that while PBL and PjBL individually support swimming skill development, their integration within a single instructional framework produces superior learning outcomes.

Discussion

The findings of this study are consistent with previous research demonstrating the effectiveness of student-centered pedagogical approaches in swimming education, particularly problem-based learning (PBL), project-based learning (PjBL), and their pedagogical elaborations. Prior studies have shown that PBL is effective in improving freestyle swimming outcomes among secondary school students (Mafahir et al., 2025), while PjBL has been reported to enhance freestyle and butterfly swimming performance

(Rusli et al., 2025). In addition, the integration of PjBL with multimedia learning has been found to improve breaststroke swimming outcomes (Mashud et al., 2023), and the combination of PjBL with peer assessment has demonstrated positive effects on freestyle swimming skill development (Rusli et al., 2025). These findings provide a strong empirical foundation for the present study and support the effectiveness of student-centered learning models in swimming instruction.

Building upon this body of research, the present study extends existing knowledge by demonstrating that the integration of multiple pedagogical approaches within a single instructional framework yields superior learning outcomes compared with the application of a single learning model. The consistent improvements observed across all swimming styles indicate that integrated learning (IL) offers a more comprehensive learning environment that supports both technical skill acquisition and learner engagement. Similar benefits of pedagogical integration have been reported in other academic disciplines, including industrial engineering education through the elaboration of PBL and PjBL (Caldwell, 2019), religious education through the integration of PBL and flipped learning (Nugraha et al., 2024), and midwifery education through the combination of PBL and case-based learning (Xie et al., 2024). The convergence of findings across disciplines suggests that integrated pedagogical approaches activate general learning mechanisms that transcend subject-specific boundaries.

A key contribution of this study is the empirical comparison between IL-based instruction and single-model approaches (PBL and PjBL). The results indicate that IL produces a significantly larger effect size than either PBL or PjBL implemented independently, while no substantial difference was found between PBL and PjBL. This finding suggests that the added value of IL lies not in the dominance of a particular model, but in the synergistic interaction among multiple pedagogical components. Evidence from other fields supports this interpretation. For example, a substantial increase in classroom engagement was reported when PBL was integrated with artificial intelligence tools such as ChatGPT compared with conventional instruction (Ramos & Condotta, 2024). Similarly, PBL supported by virtual reality has been shown to enhance learning motivation more effectively than traditional approaches (Chen et al., 2021). The integration of PBL, collaborative learning, and synchronous digital platforms has also been found to maximize online learning outcomes (Hendarwati et al., 2021).

Further support for the superiority of pedagogical integration can be found in studies examining higher-order learning outcomes. The elaboration of PjBL with a multidimensional curriculum model has been shown to enhance students' thinking processes and knowledge acquisition (Vidergor, 2022), while the integration of PBL and guided discovery learning has resulted in significant improvements in interpersonal skills and critical thinking abilities (Mardi et al., 2021). These findings align closely with the present results and suggest that integrated pedagogical approaches are particularly effective in promoting complex learning processes that extend beyond surface-level skill acquisition.

The inclusion of digital learning media within the IL framework likely played a critical role in enhancing swimming learning outcomes. Previous research has demonstrated that the use of diverse instructional models, learning approaches, and digital teaching materials within a single learning environment produces stronger learning effects than reliance on one or two conventional approaches (Akkaya & Mirzeoğlu, 2024). In higher education contexts, digital-based learning media are especially relevant, as they align with students' technological familiarity and learning preferences (Kasih et al., 2024). Moreover, the selection and integration of pedagogical approaches, learning materials,

and digital media should be adapted to learners' characteristics, educational level, and broader educational context (Apidogo et al., 2024).

Peer assessment represents another important component of the IL model. By engaging students in evaluating their own and their peers' performance, peer assessment fosters reflective learning, responsibility, and critical judgment. Importantly, peer assessment has been shown to address persistent challenges in group-based learning environments, such as social loafing, free-rider effects, and perceived unfairness in assessment (Lin et al, 2021; Lee & Lim, 2012; Loughry et al., 2007; Kennedy, 2005). The integration of peer assessment within IL-based swimming instruction likely contributed to more equitable participation and sustained engagement, thereby supporting the observed improvements in learning outcomes.

Despite the robustness of these findings, the limited number of studies directly comparing integrated pedagogical approaches with single-model instruction in swimming education remains a notable gap in the literature. Consequently, caution is warranted when generalizing these results to different educational levels or contexts. Future research should explore the application of integrated learning models in primary and secondary school settings, as well as examine their long-term effects through longitudinal designs.

In conclusion, the present study provides strong empirical support for the effectiveness of integrated learning in swimming education. By synthesizing multiple pedagogical approaches within a coherent instructional framework, IL offers a powerful alternative to single-model instruction and contributes meaningfully to the advancement of pedagogical practices in physical education.

CONCLUSION

This study confirms that integrated learning (IL)-based swimming instruction significantly enhances students' swimming learning outcomes and produces stronger effects than single-model approaches, namely problem-based learning (PBL) and project-based learning (PjBL). The integration of multiple pedagogical strategies—combining problem-solving, project-based activities, digital learning media, and peer assessment—offers clear advantages over the isolated use of individual instructional models.

Despite these promising findings, empirical evidence on integrated pedagogical approaches in swimming education remains limited, particularly across different educational levels. Future research should therefore examine the application of IL-based instruction in primary and secondary school contexts and explore the long-term sustainability of learning outcomes through longitudinal and comparative studies.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this study.

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