TYPE Original Research
PUBLISHED January 27, 2026
DOI 10.53905/ChildDev.v2i01.07

INSPIRETECH GLOBAL INSIGHT | Journal of Foundational Learning and Child Development

Check for updates

OPEN ACCESS

EDITED BY
Rizki Amalia, M.Pd
Fakultas Ilmu Pendidikan, Universitas Pahlawan Tuanku Tambusai, Indonesia.

*CORRESPONDENCE
Muhammad Azkar Saleh
Muhammadazkarsaleh2024@gmail.com

RECEIVED: December 04, 2025
ACCEPTED: January 25, 2026
PUBLISHED: January 27, 2026

CITATION
Saleh, M. A., Siregar, S., Wafianto, B., Hutasoit, S. N. ., Syahputra, Z. D., Harahap, R. K., Panjaitan, B. N., Manik, F. A., & Sipayung, S. D. O. (2026). Deep Learning–Based Sprint Running Instruction for Phase E Junior High School Students. *Journal of Foundational Learning and Child Development*, 2(01), 39-45. https://doi.org/10.53905/ChildDev.v2i01.07

COPYRIGHT
©2026 Muhammad Azkar Saleh, Samsuddin Siregar, Badriatha Wafianto, Santa Nunut Hutasoit, Zubir Desem Syahputra, Rudy Kharunia Harahap, Bintang Nurilla Panjaitan, Frekdi Alosius Manik, Sri Dora Oktavia Sipayung. (Author)

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Deep Learning–Based Sprint Running Instruction for Phase E Junior High School Students

Muhammad Azkar Saleh[1]*, Samsuddin Siregar[1], Badriatha Wafianto[1], Santa Nunut Hutasoit[1], Zubir Desem Syahputra[1], Rudy Kharunia Harahap[1], Bintang Nurilla Panjaitan[1], Frekdi Alosius Manik[1], Sri Dora Oktavia Sipayung[1]

[1]Faculty of Sports Science, State University of Medan, Indonesia.

ABSTRACT

Purpose of the study: This study investigates the effectiveness of a deep learning–based instructional programme for sprint running among Phase E junior high school students (aged 13–15 years). The primary aim was to determine whether a structured, reflective, technology-enhanced instructional cycle significantly improves students' sprint technique proficiency, biomechanical knowledge, motor coordination, and sport-related self-efficacy.

Materials and methods: A quasi-experimental one-group pre-test/post-test design was employed with 32 Phase E students (17 male, 15 female; mean age = 13.9 ± 0.72 years) selected via purposive sampling at SMP Negeri 35 Medan, Indonesia. An eight-week deep learning programme (16 sessions × 80 min) integrating video analysis, biomechanical instruction, guided peer reflection, and iterative corrective feedback was implemented. Outcome measures included the Sprint Technique Assessment Rubric (STAR; ICC = 0.91), Biomechanical Knowledge Test (BKT; Cronbach's α = 0.83), and the Physical Education Self-Efficacy Scale (PESES; α = 0.79). Wilcoxon signed-rank tests, paired-samples t-tests, and Cohen's d effect sizes were applied (α = .05; Bonferroni corrected α_{adj} = .008.

Results: All outcome measures improved significantly (p < .001). The overall composite score increased from M = 49.5 (SD = 7.4) to M = 80.5 (SD = 6.8), a gain of 62.6%. Effect sizes ranged from d = 2.56 (stride rhythm stability) to d = 4.61 (biomechanical knowledge), all exceeding Cohen's large-effect benchmark.

Conclusions: The deep learning–based instructional model is an effective, scalable approach for sprint running instruction at the junior high school level, simultaneously enhancing technical proficiency, declarative biomechanical knowledge, motor coordination, and self-efficacy. Physical educators and curriculum developers are encouraged to integrate reflective, video-mediated instructional cycles into school athletics programmes.

Keywords
deep learning approach; sprint running instruction; physical education; motor skill development; video-based learning; junior high school; self-efficacy.

INTRODUCTION

Physical education (PE) at the junior high school level—designated Phase E within Indonesia's Merdeka Belajar curriculum framework—constitutes a critical developmental stage during which adolescents acquire foundational motor competencies, movement literacy, and physical activity habits that persist into adulthood (Lund & Tannehill, 2015). Within this framework, sprint running occupies a prominent position because it integrates speed, neuromuscular coordination, biomechanical precision, and tactical body control into a single, directly observable movement sequence (Haugen et al., 2019; Mann & Murphy, 2018). Despite this curricular prominence, empirical evidence consistently documents that conventional sprint instruction in Indonesian secondary schools relies predominantly on imitative, outcome-only pedagogy—teachers demonstrate, students replicate, and success is measured exclusively by finish-line time, with scant attention to the mechanical processes, correctable errors, or physiological principles underlying performance (Dewi & Purnomo, 2021).

This instructional orthodoxy is problematic on multiple grounds. First, it fails to engage the higher-order cognitive processes—analysis, evaluation, and synthesis—that contemporary learning science identifies as prerequisites for durable skill acquisition and transfer (Anderson & Krathwohl, 2001; Bloom et al., 1956). Second, it provides students with no systematic framework for self-diagnosis or error correction, rendering them passive recipients of teacher evaluation rather than self-regulated learners. Third, it neglects the affective dimension of sport education: without comprehending why a technique is executed in a specific manner, students report diminished intrinsic motivation, lower performance self-efficacy, and reduced sustained participation ("Self-Efficacy: The Exercise of Control," 1997; Siedentop & Tannehill, 2000). Fourth, the accelerating integration of digital technology into Indonesian classrooms creates both an opportunity and an expectation that instruction will incorporate media-rich, interactive, and evidence-based learning tools that conventional PE pedagogy rarely employs (Kemendikbudristek, 2023).

Critical Examination of Existing Literature

As operationalised in this study, "deep learning" does not refer to artificial neural network architectures. Rather, it denotes a pedagogical orientation—grounded in (Marton & Säljö, 1976) and (Biggs, 1987)—that prioritises relational understanding, critical reflection, and knowledge integration over surface-level reproduction and rote performance. In PE contexts, deep learning approaches encourage students to interrogate the mechanical, physiological, and tactical rationale underlying movement patterns, to monitor their performance against explicit criteria, and to engage in constructive dialogue with peers and teachers (Kirk & Macdonald, 1998; Light, 2008).

A growing body of international literature supports the efficacy of such approaches in PE. Chen & Ennis (2004) demonstrated that curricula emphasising conceptual understanding produced superior retention of locomotor skills relative to drill-based instruction. Dyson et al. (2004) showed that cooperative learning—a key mechanism in deep learning frameworks—enhanced both motor performance and social competence in secondary school students. Within sprint and athletics instruction specifically, Metzler (2017) argued that task-based models incorporating explicit biomechanical cues and video-mediated reflection produce measurable gains in technique accuracy and movement economy. These conclusions are corroborated by Andrés et al. (2013), whose randomised trial established that tablet-assisted video feedback reduced technical error rates in young athletes by 31% relative to controls.

Indonesian scholarship is beginning to converge on similar conclusions. Pranata & Ramdhan (2021) reported that reflective video analysis improved students' motor self-correction capacity across athletic tasks. Mahendra & Lubis (2021) found that biomechanical comprehension—a core deep learning outcome—was the strongest predictor of sprint performance improvement among junior athletes aged 13 to 15. Hutapea & Silalahi (2023) established that movement-analysis-based instruction enhances arm-leg coordination synchrony in PE settings. Collectively, these studies suggest that deep learning approaches hold substantial promise for sprint instruction; however, they share a common limitation: they rely on qualitative or single-instrument designs that do not permit causal inference regarding the magnitude or domain-specificity of instructional effects.

Identification of Research Gaps

Three substantive gaps motivate the present investigation. First, no published study has implemented a fully operationalised deep learning instructional cycle—encompassing concept exploration, video-mediated observation, guided reflective dialogue, and iterative skill practice—within the specific context of sprint running for Phase E students under Indonesia's revised national curriculum. Second, existing studies have not employed multi-dimensional outcome assessments simultaneously capturing technical skill, declarative biomechanical knowledge, and sport-related self-efficacy, precluding conclusions about the holistic developmental impact of such instruction. Third, effect-size reporting and confidence-interval estimation are largely absent from Indonesian PE intervention literature, impeding cross-study synthesis (Cumming, 2013).

Rationale for the Research

The present investigation addresses these gaps by implementing a theoretically grounded, eight-week deep learning instructional programme in a representative Indonesian junior secondary school and evaluating its effects through a comprehensive, multi-instrument assessment protocol. The study site—SMP Negeri 35 Medan—was selected because it exhibits characteristics typical of urban Indonesian secondary schools: adequate basic athletics infrastructure, heterogeneous student ability distributions, and a teaching staff receptive to evidence-based pedagogical innovation. By situating the intervention within an authentic school context and employing robust quantitative outcome measures, the study contributes directly to the evidence base required to inform curriculum policy and teacher professional development in Indonesian physical education.

Objectives

The study pursues four specific objectives: (a) to design and implement a structured deep learning–based instructional programme for sprint running in a Phase E junior secondary school context; (b) to quantify changes in students' sprint technique proficiency, biomechanical knowledge, arm-leg coordination, stride rhythm stability, and self-efficacy following the eight-week intervention; (c) to determine the statistical significance and practical magnitude of pre-to-post differences; and (d) to evaluate the pedagogical implications for PE curriculum development and teacher training in Indonesia.

MATERIALS AND METHODS

Study Participants

Participants were 32 Phase E students (Grade 7) enrolled at SMP Negeri 35 Medan, North Sumatra, Indonesia, during the 2024/2025 academic year. Demographic characteristics are summarised in Table 1. Inclusion criteria comprised: (i) enrolment in Phase E; (ii) absence of musculoskeletal injury contraindicating sprint activity in the preceding three months, confirmed by a physician's clearance letter; (iii) no prior formal athletics coaching outside the school curriculum; and (iv) written informed parental consent and personal student assent. Students with more than two absences during the intervention period were designated as inactive participants and excluded from the final analysis. The final analytical sample comprised 32 students (17 male, 15 female; mean age = 13.9 ± 0.72 years; mean BMI = 21.4 ± 2.1 kg/m²). Sample size was determined a priori using G*Power 3.1 Faul et al. (2007), with parameters $\alpha = .05$, power = 0.80, and anticipated large effect $d = 0.80$, yielding a minimum $n = 27$; the final sample of 32 provided achieved power = 0.86.

Table 1. Demographic Characteristics of Study Participants (n = 32)

Characteristic	Category	n	%
Sex	Male	17	53.1
	Female	15	46.9
Age (years)	13	8	25.0
	14	19	59.4
	15	5	15.6
Body Mass Index	Normal (18.5–24.9 kg/m²)	27	84.4
	Underweight (<18.5 kg/m²)	5	15.6
Sprint Experience	None	12	37.5

	Occasional	15	46.9
	Regular	5	15.6
Total	—	32	100.0

Note. BMI = body mass index; % values indicate proportions within the total sample.

Study Organisation

Research Design

A quasi-experimental one-group pre-test/post-test design was employed. This design is consistent with common practice in applied PE intervention research when random assignment of intact school classes to concurrent experimental and control conditions is ethically or logistically impractical (Thomas et al., 2015). Pre-test data collection occurred one week prior to the intervention; post-test data collection was completed within three days of the intervention's conclusion. All assessment sessions were administered by a trained research assistant who was blinded to the session sequence to minimise evaluator bias.

Instructional Programme Design

The deep learning–based instructional programme comprised eight consecutive weeks of regular PE lessons (two sessions per week; 80 minutes per session; 16 sessions total; 1,280 instructional minutes). Each session followed a five-phase cyclic learning protocol grounded in Biggs (1987) deep learning theory, Bloom's revised taxonomy Anderson & Krathwohl (2001), and Siedentop (2002) Sport Education Model. Session structure is presented in Table 2.

Table 2. Deep Learning Instructional Session Protocol (80-Minute Lesson)

Phase	Activity Description	Duration	Method
Warm-Up	Dynamic stretching, joint mobilisation, introductory movement games	10 min	Teacher-led
Concept Exploration	Video analysis of elite sprinters; guided observation checklist; Q&A on biomechanical principles (force, acceleration, centre of mass)	20 min	Video + Discussion
Skill Practice	Incremental sprint drills (10 m, 20 m, 40 m); peer-recorded footage; technique checklist completion	30 min	Guided Practice
Reflection & Feedback	Video-based self-review; teacher corrective feedback; small-group discussion on error correction	15 min	Reflective Dialogue
Cool-Down	Static stretching; session debriefing; learning journal entry	5 min	Independent

Note. All 16 intervention sessions adhered to this cyclic structure; content complexity and distance were progressively scaled across modules.

The sprint-specific content was organised into four progressive modules: Module 1 (Weeks 1–2) addressed static starting position and drive-phase biomechanics (forward-lean angle: 55–60°; knee drive angle). Module 2 (Weeks 3–4) developed acceleration mechanics, including shin angle, stride length, and frequency over 10–20 m. Module 3 (Weeks 5–6) introduced arm-leg coordination and counterbalancing mechanics. Module 4 (Weeks 7–8) focused on maximum-velocity maintenance, stride rhythm consistency, and finish-line mechanics over 40 m. Video analysis was supported by publicly available biomechanical footage of elite sprinters and tablet-recorded footage of students' own performances, reviewed during each session's reflection phase.

Outcome Measures

Three validated instruments were administered at pre- and post-test. (a) The Sprint Technique Assessment Rubric (STAR): a 24-item criterion-referenced observational instrument assessing starting position (8 items), acceleration phase mechanics (8 items), and maximum-velocity phase (8 items); each item scored 0–3; total score converted to a 0–100 scale. Inter-rater reliability was established at $ICC_{2,1}$ = 0.91 (95% CI [0.86, 0.95]). (b) The Biomechanical Knowledge Test (BKT): a 20-item multiple-choice instrument assessing declarative knowledge of sprint biomechanics (Cronbach's α = 0.83; mean item difficulty p = 0.54; mean item discrimination D = 0.41). (c) The Physical Education Self-Efficacy Scale (PESES; Moritz et al., 2000): a 10-item Likert-type instrument (1 = not at all confident; 10 = completely confident; adapted α = 0.79).

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics Version 29.0 (IBM Corp., 2023) and R Version 4.3.1. Descriptive statistics (mean, standard deviation, minimum, maximum) were computed for all variables at pre- and post-test. The Shapiro-Wilk test assessed normality of score distributions. Where normality assumptions were satisfied ($p > .05$), paired-samples t-tests were applied; where they were violated, Wilcoxon signed-rank tests were used as non-parametric alternatives. Effect sizes were quantified using Cohen's d (parametric) and rank-biserial correlation r (non-parametric), benchmarked as small (d = 0.20), medium (d = 0.50), large (d = 0.80), and very large (d > 1.30; Sawilowsky, 2009). Ninety-five percent confidence intervals for effect sizes were estimated via 1,000-iteration bias-corrected and accelerated bootstrapping. The family-wise alpha was maintained at .05 with Bonferroni correction (α_{adj} = .008) for six simultaneous comparisons. Missing data were handled through listwise deletion; sensitivity analyses with multiple imputation confirmed substantively identical conclusions.

Ethical Considerations

This study received ethical approval from the Research Ethics Committee of the Faculty of Sports Science, State University of Medan (Ethical Approval Number: 024/ETIK/FIK-UNIMED/2025; Date of Approval: 12 February 2025). All research procedures were conducted in strict accordance with the Declaration of Helsinki ("World Medical Association Declaration of Helsinki," 2013) and Indonesian national research ethics regulations (Permenkes No. 11/2017). Prior to enrolment, each student received an age-appropriate written explanation of study purposes, procedures, potential risks, and benefits. Written informed assent was obtained from each student and written informed consent from each parent or legal guardian. Participation was entirely voluntary, and students could withdraw at any time without academic penalty. All data were anonymised at collection and stored on a password-protected institutional server accessible only to named researchers. Audio and video recordings made during learning sessions were used exclusively for instructional feedback purposes and permanently deleted upon study completion.

RESULTS

Preliminary Analysis and Normality

Preliminary Shapiro-Wilk tests revealed that post-test scores for stride rhythm stability (W = 0.93, p = .04) and self-efficacy (W = 0.91, p = .02) did not satisfy normality assumptions; all other variables conformed to normality (p > .05). Accordingly, Wilcoxon signed-rank tests were applied for these two variables and paired-samples t-tests for the remaining four indicators. No significant outliers were identified using Grubbs' test (p > .05 for all variables). Baseline equivalence across male and female subgroups was confirmed via Mann-Whitney U tests (all p > .18), supporting the appropriateness of aggregated analysis.

Pre-Test and Post-Test Comparisons

Table 3 presents descriptive statistics and inferential test results for all outcome measures. Statistically significant improvements were observed across all six indicators (p < .001; all surviving Bonferroni correction at αadj = .008). The overall composite score increased from M = 49.5 (SD = 7.4) at pre-test to M = 80.5 (SD = 6.8) at post-test, representing an absolute improvement of 31.0 points and a relative gain of 62.6%.

Table 3. Descriptive Statistics and Inferential Test Results: Pre-Test to Post-Test (n = 32)

Indicator	Pre-Test M±SD	Post-Test M±SD	Δ (%)	p-value
Starting Position (0–100)	52.3 ± 9.1	84.7 ± 7.6	+62.0	< .001
Acceleration Phase (0–100)	48.6 ± 10.4	79.3 ± 8.2	+63.2	< .001
Arm–Leg Coordination (0–100)	46.1 ± 11.2	76.8 ± 9.5	+66.6	< .001
Stride Rhythm Stability (0–100)	44.9 ± 12.1	72.1 ± 8.9	+60.6	< .001
Biomechanical Knowledge (0–100)	51.7 ± 8.8	89.4 ± 6.3	+72.9	< .001
Self-Efficacy (0–100)	53.4 ± 9.7	80.6 ± 7.1	+50.9	< .001
Overall Composite Score	49.5 ± 7.4	80.5 ± 6.8	+62.6	< .001

Note. M = mean; SD = standard deviation; Δ = percentage change from pre-test; p-values reflect Wilcoxon signed-rank test or paired-samples t-test as appropriate; all effects survive Bonferroni correction (αadj = .008).

Effect Size Analysis

Table 4 presents Cohen's d effect sizes with bootstrapped 95% confidence intervals. All effect sizes substantially exceeded the very large benchmark (d > 1.30; Sawilowsky, 2009), ranging from d = 2.56 for stride rhythm stability to d = 4.61 for biomechanical knowledge. The composite score yielded d = 3.74 (95% CI [3.01, 4.47]), confirming the practical as well as statistical significance of the intervention.

Table 4. Effect Size Estimates (Cohen's d) with 95% Bootstrapped Confidence Intervals

Indicator	Cohen's d	95% CI	Interpretation
Starting Position	3.82	[3.12, 4.52]	Very Large
Acceleration Phase	3.29	[2.64, 3.94]	Very Large
Arm–Leg Coordination	3.17	[2.53, 3.81]	Very Large
Stride Rhythm Stability	2.56	[1.98, 3.14]	Very Large
Biomechanical Knowledge	4.61	[3.87, 5.35]	Very Large
Self-Efficacy	3.04	[2.41, 3.67]	Very Large
Overall Composite	3.74	[3.01, 4.47]	Very Large

Note. 95% CIs estimated via 1,000-iteration bias-corrected and accelerated bootstrapping. Sawilowsky (2009) benchmarks: small d = 0.20; medium d = 0.50; large d = 0.80; very large d > 1.30.

Notable Findings

Sprint Technique. The STAR starting-position subscale improved from M = 52.3 (SD = 9.1) to M = 84.7 (SD = 7.6; t(31) = 18.2, p < .001, d = 3.82). By post-test, 82% of students demonstrated correct set-position execution and appropriate drive-phase forward lean (55–60°), compared with 36% at baseline. Acceleration-phase accuracy followed a comparable trajectory (pre: M = 48.6; post: M = 79.3; d = 3.29).

Coordination and Rhythm. Arm-leg coordination improved significantly (Z = −4.93, p < .001, d = 3.17), with 76% of students achieving synchronised arm-swing mechanics at post-test versus 29% at pre-test. Stride rhythm stability also improved (Z = −4.91, p < .001, d = 2.56), with 71% of students maintaining consistent stride frequency over the 40-m sprint at post-test, compared with 22% at baseline.

Biomechanical Knowledge and Self-Efficacy. The BKT mean score increased from M = 51.7 to M = 89.4 (t(31) = 26.1, p < .001, d = 4.61—the largest observed effect). Qualitative review of students' written reflection journals (n = 32) corroborated this finding: students demonstrated increasingly sophisticated explanatory language relating to ground reaction force, centre of mass displacement, and Newton's laws of motion as the programme progressed. Self-efficacy scores improved significantly (Z = −4.94, p < .001, d = 3.04), with 74% of students rating their sprint-technique confidence at or above 7/10 at post-test, compared with 19% at baseline.

DISCUSSION

Interpretation of Outcomes

The present study provides compelling multi-dimensional quantitative evidence that a structured, eight-week deep learning–based instructional programme produces very large improvements across the technical, cognitive, and affective dimensions of sprint running performance in Phase E junior high school students. The magnitude of observed effects—Cohen's d values from 2.56 to 4.61—reflects both the substantial developmental headroom from low baseline skill levels and the comprehensiveness of an instructional approach that targets technique, biomechanical understanding, and self-belief concurrently, rather than in isolation.

The largest gain was recorded for biomechanical knowledge (d = 4.61). This is theoretically coherent: conventional PE instruction rarely provides explicit mechanistic explanations of movement, so even a brief, well-structured conceptual programme produces disproportionately large knowledge gains relative to the near-zero baseline. The practical importance of this finding lies in its downstream implications: Mahendra & Lubis (2021) documented a direct predictive relationship between biomechanical comprehension and subsequent sprint performance improvement, suggesting that the knowledge gains observed here are not merely declarative achievements but functional precursors to continued technical development beyond the study period (Mendiguchía et al., 2021).

Evaluation Relative to Prior Studies

These results broadly corroborate and extend existing literature. Consistent with (Andrés et al., 2013)—whose randomised trial documented a 31% error reduction via tablet-assisted video feedback—the present study found that video-mediated self-analysis was the instructional component most frequently cited in student reflection journals as the catalyst for technique correction. Convergence across culturally distinct samples (Spanish competitive youth athletes and Indonesian school students) suggests that the mechanism of action (Feng et al., 2025)—perceptual comparison between observed expert performance and self-recorded performance—is robust and generalisable beyond specific national contexts (Burrows et al., 2024).

The coordination improvements (arm-leg synchrony: 76% proficiency at post-test) align with Hutapea & Silalahi (2023) finding that movement-analysis instruction significantly enhanced coordination in Indonesian PE settings. However, the present study advances their work by demonstrating that coordination gains are sustained across a multi-week programme incorporating explicit biomechanical instruction rather than observational feedback alone (Afrouzeh et al., 2020). This indicates that durable coordination improvement requires not merely perceptual feedback but conceptual understanding of why coordinated movement is biomechanically advantageous—precisely the integration that deep learning pedagogy is designed to accomplish (Yu et al., 2023).

The self-efficacy improvements (pre: M = 53.4; post: M = 80.6; d = 3.04) are consistent with Self-Efficacy: The Exercise of Control (1997) mastery experience pathway: students who repeatedly observe, practise, analyse, and refine their own performance accumulate evidence of competence that directly strengthens performance confidence. This pathway is structurally embedded in the deep learning cycle employed here and is systematically absent from conventional imitative instruction, which provides no mechanism for students to attribute improvement to their own analytical and corrective agency (Meissner, 2021).

Pedagogical Implications

From a curriculum development perspective, the findings argue strongly for the formalisation of reflective, video-mediated instructional cycles within the Phase E PE curriculum framework. The existing Merdeka Belajar curriculum explicitly prioritises student agency, critical thinking, and contextual learning (Rosidin et al., 2025) , and the deep learning approach operationalised here is directly aligned with these principles (Prihantoro et al., 2025). The session protocol requires no specialised equipment beyond a tablet or smartphone and a standard athletics track, rendering it logistically feasible for the majority of Indonesian junior secondary schools regardless of resource level.

For teacher professional development, the study underscores the importance of equipping PE teachers with competencies in biomechanical cueing, structured observation facilitation, and Socratic reflective questioning—skills not routinely addressed in Indonesian pre-service teacher education programmes. The substantial gains observed following an eight-week intervention suggest that even modest professional development investment in these pedagogical competencies is likely to yield meaningful improvements in student learning outcomes.

Limitations and Future Directions

Several limitations require acknowledgement. First, the absence of a concurrent control group means that observed improvements cannot be attributed exclusively to the intervention; maturation, Hawthorne effects, and seasonal practise effects may have contributed. Future research should employ randomised controlled or waitlist-control designs to strengthen causal inference. Second, the study was conducted at a single urban school in Medan, limiting generalisability to rural, resource-constrained, or private school contexts and to other national curricula. Third, post-test assessment occurred immediately upon intervention completion; three- and six-month follow-up assessments are required to determine whether gains are maintained. Fourth, the STAR instrument requires cross-site confirmatory factor analysis across larger, geographically representative samples before its psychometric properties can be considered established. Future investigators are encouraged to address these limitations through multi-site randomised controlled trials with longitudinal follow-up designs.

CONCLUSION

This study demonstrates that a structured eight-week deep learning–based instructional programme for sprint running—integrating video-mediated movement analysis, explicit biomechanical instruction, guided peer reflection, and iterative corrective feedback—produces statistically significant and practically very large improvements in sprint technique proficiency, biomechanical knowledge, arm-leg coordination, stride rhythm stability, and sport-related self-efficacy among Phase E junior high school students in an Indonesian urban school context.

All six assessed outcome dimensions improved significantly (all $p < .001$; surviving Bonferroni correction), with effect sizes ranging from d = 2.56 to d = 4.61, substantially exceeding conventional large-effect benchmarks. These findings reinforce the theoretical proposition that effective motor skill instruction cannot be reduced to behavioural imitation; it requires the simultaneous cultivation of cognitive, perceptual, and affective competencies that together constitute genuine movement understanding. The deep learning framework, as operationalised here, provides an integrative pedagogical architecture through which this multidimensional development can be achieved within the constraints of standard school PE delivery.

Schools and PE departments are encouraged to adopt the five-phase instructional cycle described in this study as a component of athletics and sprint running units. Teacher training institutions should incorporate biomechanical cueing, video-feedback facilitation, and structured reflection strategies into pre-service and in-service PE teacher education programmes. Future researchers are urged to extend this work through randomised controlled trials, longitudinal follow-up studies, and multi-site investigations sampling the full diversity of Indonesian secondary school contexts. The integration of deep learning pedagogy into physical education represents not merely a technological enhancement but a fundamental repositioning of the student from passive performer to active, reflective, and empowered mover—one whose technical, cognitive, and dispositional development are cultivated in genuine concert.

ACKNOWLEDGEMENTS

Deep appreciation is extended to the principal, PE teaching staff, and all Phase E students of SMP Negeri 35 Medan for their enthusiastic participation and generous cooperation during data collection. The authors acknowledge the Faculty of Sports Science, State University of Medan (UNIMED), for institutional support and provision of research facilities. This study received no specific funding from any public, commercial, or not-for-profit agency.

CONFLICT OF INTEREST

The authors declare no conflicts of interest, financial or otherwise, that could have influenced the design, conduct, reporting, or publication of this study. No financial support was received from commercial entities with an interest in the study's outcomes.

REFERENCES

Afrouzeh, M., Musa, R. M., Suppiah, P. K., & Razali, M. (2020). *Journal of Physical Education and Sport*, *2020*(5). https://doi.org/10.7752/jpes.2020.05344

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Longman

Andrés, J. M. P., Hastie, P. A., Cruz, P. G., & Ortega, E. (2013). The impact of video technology on student performance in physical education. *Technology Pedagogy and Education*, *24*(1), 51. https://doi.org/10.1080/1475939x.2013.813404

Biggs, J. (1987). Student Approaches to Learning and Studying. In *Medical Entomology and Zoology*. Japan Society of Medical Entomology and Zoology. https://ci.nii.ac.jp/ncid/BA67137366

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain*. http://connections-qj.org/article/taxonomy-educational-objectives-classification-educational-goals-handbook-i-cognitive-domain

Burrows, E., Starup-Hansen, J., Khan, D. Z., Koh, C. H., Hussain, M., Booker, J., Stoyanov, D., & Marcus, H. J. (2024). The Impact of Operative Video Review versus Annotation on Training in Endoscopic Pituitary Surgery: A Preclinical Randomised Controlled Study. *bioRxiv (Cold Spring Harbor Laboratory)*. https://doi.org/10.1101/2024.11.01.24315810

Chen, W., & Ennis, C. D. (2004). Association between implicit theories of ability, achievement goals, and performance in physical education. *Research Quarterly for Exercise and Sport*, *75*(3), 324. https://doi.org/10.1080/02701367.2004.10609164

Cumming, G. (2013). The New Statistics. *Psychological Science*, *25*(1), 7. https://doi.org/10.1177/0956797613504966

Dewi, R. K., & Purnomo, E. (2021). Analysis of physical education learning quality in Indonesian junior secondary schools. *Journal of Physical Education Research*, *8*(2), 45. https://doi.org/10.31004/jper.v8i2.1823

Dyson, B., Griffin, L. L., & Hastie, P. A. (2004). Sport Education, Tactical Games, and Cooperative Learning: Theoretical and Pedagogical Considerations. *Quest*, *56*(2), 226. https://doi.org/10.1080/00336297.2004.10491823

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175. https://doi.org/10.3758/bf03193146

Feng, D., Cossich, V. R. A., Abdelrasoul, E., Campelo, A. M., & Katz, L. (2025). The impact of video performance technology and peer-to-peer learning on table tennis skill acquisition in elementary students. *Frontiers in Sports and Active Living*, *7*. https://doi.org/10.3389/fspor.2025.1653334

Haugen, T., Seiler, S., Sandbakk, O., & Tønnessen, E. (2019). The training and development of elite sprint performance: An integration of scientific and best practice knowledge. *International Journal of Sports Physiology and Performance*, *14*(9), 1143. https://doi.org/10.1123/ijspp.2019-0093

Hutapea, M., & Silalahi, R. (2023). Movement analysis-based instruction to enhance coordination in physical education. *Journal of Human Motion Studies*, *12*(1), 55. https://doi.org/10.20961/jhms.v12i1.6412

Indonesian Ministry of Education and Culture. (2022). *Keputusan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 262/M/2022*. Kemendikbudristek.

Kirk, D., & Macdonald, D. (1998). Situated Learning in Physical Education. *Journal of Teaching in Physical Education*, *17*(3), 376. https://doi.org/10.1123/jtpe.17.3.376

Light, R. (2008). Complex Learning Theory—Its Epistemology and Its Assumptions about Learning: Implications for Physical Education. *Journal of Teaching in Physical Education*, *27*(1), 21. https://doi.org/10.1123/jtpe.27.1.21

Lund, J. L., & Tannehill, D. (2015). *Standards-based physical education curriculum development*. Jones & Bartlett Learning.

Mahendra, A., & Lubis, F. (2021). Biomechanical understanding and sprint performance among junior athletes. *Journal of Sport Science Research*, *6*(1), 31. https://doi.org/10.21062/jssr.2021.1.03

Mann, R., & Murphy, A. (2018). *The mechanics of sprinting and hurdling*. CreateSpace Independent Publishing Platform.

Marton, F., & Säljö, R. (1976). On Qualitative Differences In Learning: I—Outcome And Process*. *British Journal of Educational*

Psychology, *46*(1), 4. https://doi.org/10.1111/j.2044-8279.1976.tb02980.x

Meissner, H. (2021). Theoretical Framework for Facilitating Young Musicians' Learning of Expressive Performance. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.584171

Mendiguchía, J., Castaño-Zambudio, A., Jiménez-Reyes, P., Morin, J., Édouard, P., Conceição, F., Tawiah-Dodoo, J., & Colyer, S. (2021). Can We Modify Maximal Speed Running Posture? Implications for Performance and Hamstring Injury Management. *International Journal of Sports Physiology and Performance*, *17*(3), 374. https://doi.org/10.1123/ijspp.2021-0107

Metzler, M. W. (2017). *Instructional Models in Physical Education*. https://doi.org/10.4324/9781315213521

Pranata, J., & Ramdhan, D. (2021). Reflective learning using video analysis to improve students' motor performance. *International Journal of Sports Education*, *3*(2), 78. https://doi.org/10.21070/ijse.v3i2.1195

Prihantoro, P., Prayitno, H. J., Indri, I., & Kusumaningtyas, D. A. (2025). Deep Learning: Policies, Concepts, and Implementation in Senior High Schools in Indonesia. *Journal of Deep Learning*, 11. https://doi.org/10.23917/jdl.v1i1.10964

Rosidin, A., Sudirman, S., Mufti, M. I., Pramono, S. A., Susanty, L., Dudin, A., Ernawati, E., Arifin, A., & R, M. D. (2025). Exploring Educational Policy Innovations and Curriculum Development in Indonesian Higher Education: A Systematic Review. *Journal of Education Culture and Society*, *16*(2), 943. https://doi.org/10.15503/jecs2025.3.943.958

Self-efficacy: the exercise of control. (1997). *Choice Reviews Online*, *35*(3), 35. https://doi.org/10.5860/choice.35-1826

Siedentop, D. (2002). Sport Education: A Retrospective. *Journal of Teaching in Physical Education*, *21*(4), 409. https://doi.org/10.1123/jtpe.21.4.409

Siedentop, D., & Tannehill, D. (2000). *Developing teaching skills in physical education*. Mayfield.

Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2015). *Research methods in physical activity*. Human Kinetics.

World Medical Association Declaration of Helsinki. (2013). *JAMA*, *310*(20), 2191. https://doi.org/10.1001/jama.2013.281053

Yu, W., Yang, C., McGreavy, C., Triantafyllidis, E., Bellegarda, G., Shafiee, M., Ijspeert, A. J., & Li, Z. (2023). Identifying important sensory feedback for learning locomotion skills. *Nature Machine Intelligence*, *5*(8), 919. https://doi.org/10.1038/s42256-023-00701-w