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RESEARCH ARTICLE

Video-Based Feedback in Table Tennis Training: Toward a Wearable Learning for Undergraduate Education

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Abstract: The study examined the role of video-based feedback in developing foundational skills in table tennis among undergraduate students. In physical education settings where traditional methods often rely on instructor-led demonstration and repetition, the integration of visual tools offers a way to enhance understanding and support deeper engagement with motor learning. The research focused on how recorded practice sessions could be used to improve stroke accuracy, ball control, and gameplay strategies through self-reflection and peer dialogue. A single-group experimental design was applied over an eight-week period involving 40 university students with no formal background in table tennis. Each week introduced progressively complex skill exercises, supported by student-generated video recordings using personal mobile devices. These clips served as a basis for self-review and peer exchange. Technical performance was evaluated using a structured skill assessment rubric in both pre- and post-intervention phases. Learner experiences were collected through a Likert-scale questionnaire and short written reflections. Statistical analysis showed significant improvement across all skill areas, particularly in backhand technique and rally control. Students reported that video playback enabled clearer awareness of movement errors and supported more precise adjustments over time. This replayability fostered self-awareness and active engagement. Many participants noted that feedback drawn from video felt more personal and actionable compared to traditional verbal correction. Although wearable devices were not yet deployed during the intervention, the instructional approach was intentionally designed toward wearable learning. Future integration may include smart bands or sensor-based feedback systems, enabling learners to overlay biomechanical data with video for enhanced movement analysis. The findings support broader adoption of video feedback as a reflective learning tool and highlight the potential for combining it with wearable technologies in sport education. This direction represents a promising step toward more autonomous and personalized skill development in physical activity contexts.

Keywords: video-based feedback, table tennis, skill acquisition, motor learning, self-regulated learning, physical education

1. Introduction

Learning table tennis involves more than just hitting a ball—it requires precision, timing, and highly coordinated motor skills. Traditional methods, which emphasize live coaching and repeated physical drills, have long been the foundation of skill acquisition. However, recent advances in technology are gradually transforming this process. Digital tools, particularly video-based learning, augmented and virtual reality (AR/VR), and wearable feedback devices, are now playing a significant role in supporting technical development [1–3].

Video analysis has emerged as a widely used method for enhancing movement awareness. Watching recorded performances helps learners identify subtle technical flaws, essentially serving as a visual mirror of their actions. This visual feedback is now widely recognized as a valuable supplement to verbal instruction [4, 5]. Furthermore, research by Culajara [6] found that integrating video-based presentations in physical education improved both performance outcomes and learners' conceptual understanding.

In skill-based sports like table tennis, where success hinges on rapid, complex movements, multimedia learning has garnered significant interest. Han [7] demonstrated that internet multimedia applications can effectively support the teaching of complex technical movements. These tools are particularly useful because they not only provide replayable visual content and facilitate step-by-step correction—which can increase learners' self-efficacy and engagement—but also align with broader research confirming the effectiveness of digital video in motor skill acquisition [4, 8]. The ability to pause, replay, and analyze practice sessions contributed to greater confidence and engagement.

This study seeks to examine the educational value of video-based learning in table tennis skill development among undergraduates. The research focuses on assessing the effectiveness of using recorded practice sessions as a supplementary instructional method. Specific objectives include analyzing which video formats most effectively support skill acquisition and evaluating the outcomes of video-based teaching on foundational movements, particularly forehand and backhand strokes. The goal is to better understand how learners

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may benefit from combining visual feedback with physical practice in a structured educational setting.

2. Literature Review

2.1. Foundations of video-based feedback and motor skill learning

Recent years have seen a surge in the integration of digital tools into sports education, particularly in activities that require precise motor coordination like table tennis. Video-based learning, in this context, has attracted a great deal of interest due to its ability to provide visual clarity, self-reflection, and immediate feedback. Learners often describe the experience as "like reviewing a mirror of your own performance," where technical flaws become more visible and actionable.

Studies have confirmed that video feedback supports not only technical skills but also motivation and cognitive understanding. For example, video presentations have been shown to enhance movement awareness and learning efficiency in physical education environments [6]. In table tennis, multimedia tools have proven effective in breaking down difficult movements into observable elements, offering learners the opportunity to revisit and correct subtle techniques [7]. An applied study by Chen et al. [9] also revealed that structured table tennis electives, especially those enhanced with video-based tools, can improve physical fitness and technical proficiency among undergraduates.

In table tennis, digital teaching materials can stimulate higher-order thinking, as a study showed that a visual-based instructional design led to stronger cognitive gains among students [8], which may explain why blended methods—combining face-to-face coaching with video analysis—continue to grow in popularity.

Furthermore, broader evidence suggests that immersive virtual technologies and feedback systems improve decision-making and body control across sports [10]. However, it appears that even simple, consistent video feedback, especially when self-recorded, can significantly impact skill development without the need for advanced equipment [11]. Ultimately, the recurring theme across studies is that feedback—when well-timed and visually supported—helps learners progress faster and more confidently.

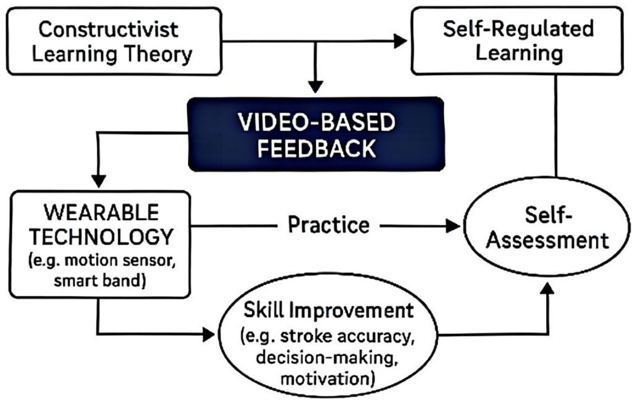
2.2. Related works on digital feedback in motor learning

Mödinger et al. [4] systematically reviewed video-based feedback methods and confirmed their benefits in enhancing motor learning efficiency. Similarly, Liebermann et al. [5] emphasized that visual tools not only enhance technical performance but also cognitive engagement when integrated effectively into physical education curricula.

Geisen and Klatt [10] further observed that extended reality systems, when integrated with real-time feedback, can enhance learners' spatial and kinesthetic understanding during sports skill training. Li et al. [2] added that motion capture systems in virtual environments are becoming increasingly accessible and accurate for skill-specific feedback.

Emerging technologies also support real-time diagnostic and instructional feedback. For instance, Milasi et al. [3] examined internet of things (IoT)-enabled systems for sport applications and found promising results in performance analytics. Liebermann et al. [12] laid foundational principles on integrating smart technologies into sports performance settings.

Figure 1
Theoretical framework of video-based and wearable learning in table tennis skill development



2.3. Role of wearable technologies in sport skill acquisition

In the specific context of table tennis, Ma et al. [1] and Shi et al. [13] provided frameworks for integrating biomechanical sensors to enhance learner awareness, although these approaches are often still experimental. Wu et al. [14] contributed further evidence that immersive environments leveraging multi-sensory input can deepen motor perception and stroke consistency. Voeikov et al. [15] proposed a real-time video analysis system tailored for table tennis, highlighting the future of AI-based performance feedback. As synthesized in Figure 1, our framework connects video-based feedback with wearable sensing to support self-regulated practice, self-assessment, and iterative skill improvement.

This framework illustrates the relationship between constructivist learning theory and self-regulated learning in the context of skill development. Video-based feedback, enhanced by wearable technologies, facilitates practice, self-assessment, and iterative improvement in technical skills such as stroke accuracy, decision-making, and motivation.

These findings collectively suggest that structured use of video tools, with potential integration of advanced feedback systems, offers a promising path toward improved learning outcomes in high-speed skill sports like table tennis.

3. Research Methodology

3.1. Research design

A single-group experimental design was implemented to examine the impact of integrating video-based feedback on skill acquisition in table tennis. The program lasted for eight weeks and was structured to gradually increase in technical complexity. The weekly curriculum involved isolated skill development (e.g., forehand, backhand, and wall rally), followed by integrated gameplay. Participants used their own mobile devices to record practice sessions, encouraging ownership and self-monitoring throughout the intervention [4, 6, 7]. The week-by-week learning experience plan is summarized in Table 1.

Although wearable devices such as motion sensors or smart bands were not deployed in this intervention, the design was conceptually aligned with the potential integration of such tools in future research. Based on current evidence, wearable devices can

Table 1
Learning experience plan

Week	Activity	Description	Teaching method	Expected outcome
1	Introduction to basic skills	Overview of forehand, backhand, and ball bouncing techniques	Demonstration and group practice	Students understand and demonstrate basic techniques
2	Forehand and backhand drills	Focused practice on strokes using video recordings	Video recording and peer feedback	Improved technique and consistency in strokes
3	Wall rally practice	Practice with wall hits to build ball control	Video analysis and guided practice	Increased control and precision in rallies
4	Partner Drill—Forehand	Paired forehand stroke practice	Video recording and self-assessment	Enhanced coordination and response time in forehand rallies
5	Partner drill – backhand	Backhand rally drills with partners	Video-based feedback	Improved backhand control and consistency
6	Combination drills	Alternating forehand–backhand during rally	Combined video and real-time feedback	Improved transition and fluidity in stroke changes
7	Skill integration	Real-game simulation incorporating all basic skills	Group play and video recording	Improved strategy and skill integration
8	Final evaluation	Posttest and video performance review	Skill test and video feedback	Measurable improvement through reflective learning

enable real-time biomechanical tracking to supplement video analysis, such as measuring joint angles, movement efficiency, and stroke velocity [1, 2, 16]. In turn, this would support more nuanced motor learning by allowing students to correlate visual feedback with sensor data for detailed performance insights [3, 5, 12].

The educational approach was informed by constructivist and self-regulated learning theories. Students were encouraged to review their recordings, reflect on movement patterns, and implement adjustments based on visual and peer feedback [4, 8, 11]. All sessions were recorded from multiple angles to facilitate diverse perspectives and maximize observational learning. A standardized skill rubric was used in pre- and posttest evaluations to assess changes in performance outcomes, including accuracy, control, and fluidity [9, 15, 17].

This research design aligns with current trends toward hybrid learning environments in sports education, incorporating both reflective tools and emerging technologies. While the focus remained on video-based feedback, the structure allows for future expansion into wearable-enhanced or AI-supported feedback systems [16, 18, 19].

3.2. Participants

The study involved 40 undergraduate students enrolled in a general physical education course. All participants had no formal training in table tennis, ensuring a uniform baseline. They were selected using purposive sampling to match the intervention's goal of improving beginner-level performance. Every participant completed the full eight-week training sequence and contributed to both the quantitative assessments and qualitative feedback collection.

Prior to the intervention, informed consent was obtained from all participants regarding the use of video recordings for learning and research purposes. Each student was made aware that practice sessions would be recorded for feedback and analysis and that these recordings would be handled with strict confidentiality and used solely within the educational and research framework of the study.

3.3. Instruments

Skill assessment form: a domain-specific assessment rubric was developed to systematically measure core performance indicators in table tennis skill development, including stroke accuracy, ball control, footwork coordination, and responsiveness to dynamic play situations. Each criterion was aligned with the instructional standards endorsed by national sports education bodies to ensure content validity. The rubric used a five-point ordinal scale, enabling both quantitative evaluation and diagnostic feedback. For instance, stroke accuracy was evaluated based on target zone consistency, while control involved sustained rally ability without errors.

The initial version of the rubric underwent content validation by three subject matter experts in table tennis coaching and physical education assessment. These experts reviewed the alignment between assessment criteria and instructional outcomes. Following expert review, a pilot test was conducted with a small group of students (not included in the main study) to ensure the rubric was both interpretable and practical during real-time evaluation. Minor revisions were made based on this pilot to improve clarity of descriptors and ease of scoring.

This rubric was then applied consistently during both pretest and posttest phases by two independent raters trained to ensure scoring reliability. Inter-rater reliability was calculated to ensure consistency of evaluation.

Video recording tools: Video recordings were an essential component of the intervention, serving both as a feedback mechanism for learners and as a documentation tool for instructional analysis. Each practice session was recorded using smartphones or personal devices, and students were encouraged to voluntarily film their own performances or collaborate with peers to document practice sessions. This learner-driven approach allowed participants to select filming conditions that best captured the aspects of their performance they wished to analyze, promoting autonomy and engagement in reflective learning. Details of clip types, purposes, and expected outcomes are shown in Table 2.

Rather than adhering to a strict recording protocol, students were provided with general guidelines on how to capture useful footage, including suggestions on framing, movement clarity, and session relevance. They were free to determine when, where, and how to record based on their skill focus and personal learning preferences.

After each session, video clips were uploaded to a secure platform where students could privately review their performances. The review process was supported by reflection prompts and coaching discussions,

Table 2
Analysis of video clip approach

Skill	Type of video clip	Purpose	Expected learning outcome
Ball bouncing	Video showing bouncing from multiple angles	To enhance control and coordination	Improved control and hand-eye coordination
Forehand stroke	Side view video of arm movement	To visualize posture and swing mechanics	Better precision and power in forehand strokes
Backhand stroke	Rear and side view of body mechanics	To observe balance and foot positioning	Improved stroke balance and alignment
Wall rally	Front view showing return speed	To support repetitive precision training	Enhanced timing and consistency
Forehand–backhand combo	Mid-rally footage of alternating strokes	To improve transition between techniques	Smoother stroke changes and rally dynamics
Partner drills	Two-player rally interaction	To build coordination and timing with others	Faster response and better rhythm
Game simulation	Full-match footage	To develop strategic thinking	Better decision-making under match conditions

encouraging learners to identify specific strengths and areas for improvement. Instructors also referred to selected clips during feedback sessions, helping students track their progress and make targeted corrections.

This flexible and participatory approach to video-based feedback emphasized ownership of learning while still aligning with the structured goals of the program. By capturing their performance from perspectives they deemed meaningful, students were able to develop deeper insights into their technique and refine their skills with greater self-awareness and motivation.

Learner feedback questionnaire: a structured questionnaire based on a five-point Likert scale was administered to all participants at the conclusion of the eight-week program. The instrument was designed to capture learners' subjective experiences with the video-based learning approach. Survey items addressed four key domains:

1) Perceived skill development (e.g., improvement in forehand/backhand technique, game confidence)
2) Engagement and motivation during the learning process.
3) Self-confidence and autonomy in learning table tennis.
4) Perceived usefulness of video recordings for learning and reflection.

The questionnaire served a dual purpose. First, it provided a learner-centric evaluation of the intervention, offering insights into how students experienced the process beyond what performance metrics alone could reveal. Second, it served as a triangulation tool, helping to validate findings from skill assessments through subjective self-report data. Feedback from the questionnaire also informed qualitative themes, such as learners' preferences for self-paced video review, challenges in self-filming, and the perceived role of peer collaboration.

Data analysis tools: Quantitative data from the pre- and post-intervention skill assessments were analyzed using paired-sample t-tests to determine whether there were statistically significant improvements in specific performance domains—namely, stroke accuracy, control, footwork, and rally consistency. A significance level of $p < 0.05$ was used to establish whether observed changes were likely due to the intervention rather than chance.

In parallel, responses to open-ended questionnaire items were subjected to thematic analysis. This involved coding participants' written reflections to identify recurring patterns and sentiments related to their experiences with video-based learning. Emergent themes included increased self-awareness, appreciation for the visual learning format, and recognition of peer feedback as a supportive component. These qualitative findings helped contextualize the numerical results, offering a fuller picture of the intervention's impact from both cognitive and affective learning perspectives.

Together, the combination of statistical testing and thematic interpretation allowed for a robust, mixed-methods evaluation of how video-based feedback influenced learning outcomes in the table tennis training program.

4. Results

After eight weeks of video-based learning in table tennis, the results demonstrated significant improvements in the participants' basic table tennis skills, including ball control, forehand and backhand rallies, and transitions between strokes. The analysis compared pretest and posttest scores, which indicated overall growth in the students' performance, as detailed in the following subsections.

4.1. Quantitative results

Participants showed notable improvements in both forehand and backhand strokes. In the pretest, many students struggled with consistency in ball placement and lacked precision in their strokes. However, posttest results indicated significant improvements in both skill accuracy and control. The video-based feedback, particularly using side-view and rear-view clips to visualize arm movement and posture, enabled students to make the necessary adjustments to improve stroke mechanics. These outcomes align with the findings of Richlan et al. [18], who emphasized the role of immersive video environments, and Sookhanaphibarn and Sookhanaphibarn [11], who demonstrated the benefits of self-recorded feedback in improving technical skills in table tennis.

The participants also demonstrated significant progress in ball control, especially in the wall rally drills. Pretest scores showed low proficiency in repetitive ball hits and maintaining control during longer rallies. Posttest results, however, indicated improved precision and reaction time, consistent with findings from D'Ambrosio et al. [17], who explored robotic learning systems that support rapid skill acquisition and control in table tennis.

A paired sample *t*-test was conducted to analyze the difference between pretest and posttest scores. The results showed a statistically significant improvement ($p < 0.05$) in key areas of table tennis performance, including forehand–backhand transitions, rally

Table 3
Summary of key findings for table tennis skill improvement

Skill	Pretest Mean score	Posttest Mean score	% Improvement	p-value
Forehand stroke accuracy	65	85	30%	< 0.05
Backhand stroke accuracy	60	82	36%	< 0.05
Ball control (wall rally)	58	80	38%	< 0.05
Forehand-backhand transition	63	84	33%	< 0.05
Overall rally performance	61	83	36%	< 0.05

Table 4
Analysis of skill development based on student feedback

Skill	Feedback rating	Areas of improvement identified by students	Impact of video-based learning
Forehand stroke	4.5	Better understanding of arm positioning and stroke power	Significant improvements in accuracy and consistency
Backhand stroke	4.3	Enhanced footwork and stroke precision	Increased control and balance during rallies
Ball control (wall rally)	4.6	Improved ball return speed and timing	Noticeable enhancement in precision and repetitive control
Forehand–backhand transition	4.4	Faster transitions between strokes	Better coordination and smoother transitions between forehand and backhand
Overall rally performance	4.5	Stronger rally dynamics and increased consistency	Improved ability to sustain longer rallies and react faster

consistency, and overall ball control. The improvements are presented in Table 3, which details the mean scores, standard deviations, and significant values across each assessed skill dimension. These findings support the hypothesis that video-based learning enhances the acquisition of psychomotor skills in table tennis [4, 5].

4.2. Learner experience and perceived impact

To complement the statistical analysis, a questionnaire was administered to all 40 participants to assess their perceptions of the video-based learning intervention. The feedback, rated on a Likert scale, provided insight into how effectively students believed video-based learning improved specific table tennis skills.

The majority of participants indicated that reviewing their videos helped them identify weaknesses and correct mistakes more effectively than traditional instructor feedback alone. This observation supports earlier work by Liebermann et al. [12], who highlighted the value of learner-controlled feedback loops, and aligns with Ross [19], who emphasized imagery and self-reflective techniques in performance training.

The student feedback highlighted several key areas of improvement:

1) Forehand Stroke: Students rated this skill highly (4.5), citing a better understanding of arm positioning and stroke power due to the visual cues provided by video analysis.
2) Ball Control (Wall Rally): With the highest feedback rating (4.6), students reported significant improvements in ball return speed, timing, and precision, which were enhanced through video-based self-assessment.
3) Overall Rally Performance: Students expressed that video feedback helped them sustain longer rallies and improve reaction time, with an average rating of 4.5.

Students consistently emphasized the benefits of self-assessment through video clips. Many noted that the ability to pause, replay, and slow down the footage made it easier to spot movement inefficiencies. Additionally, watching their own performance enabled clearer awareness of technique, posture, and timing. This reflective process increased their confidence and ownership of learning. The analysis of skill development based on student feedback is presented in Table 4.

These qualitative insights align with the quantitative improvements observed in the posttest scores, confirming that video-based learning not only facilitated technical skill development but also enhanced students' understanding and confidence in applying these skills during gameplay.

4.3. Discussion

The findings of this study suggest that video-based learning provides more than a modern alternative to traditional coaching. It functions as a tool for reflection, technical refinement, and learner autonomy in table tennis skill acquisition. Across the eight-week training period, participants demonstrated measurable improvement in fundamental areas including stroke precision, rally dynamics, and overall consistency. These outcomes highlight how access to visual feedback supports deeper understanding and faster correction of movement patterns.

A key element of the learning process was the promotion of self-regulated learning. Rather than following instructions passively, participants actively reviewed their recorded performances to identify errors and make adjustments. This iterative process of observation, evaluation, and refinement aligns with research by Mödinger et al. [4] and Liebermann et al. [5], who emphasize the value of video in supporting internalized learning cycles and motor memory consolidation.

Richlan et al. [18] described this as a virtual enhancement of perception, allowing learners to notice subtleties in posture, rhythm, and timing that may go undetected during real-time play. Their findings support the notion that video interventions promote not only performance but also perception and mental engagement.

The structure of the video feedback was another important success factor. Specific angles—such as side or rear views—allowed learners to focus on targeted aspects of their movement, including forehand mechanics and backhand footwork. This mirrors findings from Ma et al. [1] and Siregar et al. [8], who emphasized the importance of instructional video design and user-centered feedback systems in maximizing learning outcomes. Liangzi [7] also found that multimedia formats enable learners to deconstruct difficult stroke combinations by observing slow-motion transitions.

Beyond technical improvement, the intervention also enhanced learners' confidence and sense of ownership. As students engaged in self-review and performance adjustment, they developed greater self-efficacy and autonomy. This aligns with Kaeduang et al. [20], who emphasized that structured e-learning in physical education can foster self-management and reflective habits—complementing Siregar et al.'s [8] findings on the motivational and metacognitive benefits of digital learning environments.

While this study did not include wearable technology directly, the video-based approach used here opens several possibilities for future integration. Smart bands, motion trackers, or sensor-enabled clothing could enrich the video analysis experience by providing additional data on body angles, joint stability, stroke force, and timing. This type of augmentation would elevate video feedback into a fully interactive learning environment. This direction aligns with recent trends in AI-supported coaching strategies, which, as noted by Pashaie et al. [16], leverage intelligent systems to personalize training and deliver adaptive feedback in real time.

As highlighted by Liebermann et al. [5, 12], learner-controlled reviews supported by wearable data could further personalize instruction and provide actionable insights in real time. Moreover, integration with systems like those described by Ma et al. [1] or D'Ambrosio et al. [17]—which combine robotics, real-time analysis, and augmented feedback—could lead to highly adaptive, data-driven learning environments in sports education.

In summary, the study demonstrates the educational value of integrating structured video feedback in table tennis training. It also highlights the untapped potential of wearable technology in extending this model to more immersive, personalized, and data-enriched learning experiences.

5. Conclusion

This study demonstrates the practical value of using video-based feedback in table tennis instruction for undergraduate learners. Over an eight-week period, participants showed significant improvements in core skill areas such as forehand and backhand strokes, ball control, and rally transitions. These improvements were not only technical but also reflected deeper learning processes, where students actively monitored and refined their performance.

The structured use of video enabled precise feedback loops. Learners could pause, replay, and analyze their movements at their own pace. This approach supported personalized learning, reduced dependency on instructors, and increased confidence in skill development. These outcomes reinforce earlier findings on the benefits of visual learning tools in sports education, including those by Mödinger et al. [4], Culajara [6], and Liangzi [7].

Although wearable technology was not directly used in this study, the findings offer a solid foundation for future integration. The current video-based model already promotes self-assessment and technical refinement. Combining this with wearable devices—such as smart bands or motion sensors—could further enhance the experience by delivering real-time biomechanical feedback, including data on stroke accuracy, joint movement, or physiological responses. When synchronized with video playback, such data would enable a powerful dual-channel learning system.

The increasing role of digital technology in education suggests that these integrations are not only feasible but also necessary. Structured video tools combined with smart wearables can transform conventional instruction into a flexible, responsive, and learner-centered environment. Instructors gain meaningful analytics, while learners gain tools to track progress and refine skills independently.

Future research may explore the long-term retention of skills acquired through hybrid methods and evaluate their impact across different sports and populations. For now, this study affirms that video-based learning provides more than surface-level enhancement—it cultivates self-directed growth, where performance becomes visible and improvement becomes a matter of conscious choice and reflective effort.

New Knowledge Received

This study contributes to a growing understanding of the role of technology in physical education by highlighting the educational value of video-assisted instruction. Beyond confirming its effectiveness for psychomotor development, the research provides insight into how video feedback enhances self-efficacy, reflective thinking, and learner autonomy. Furthermore, the results demonstrate how integrating visual technology into sports training bridges the gap between conventional teaching practices and modern learner-centered methodologies. These insights offer a forward-looking pedagogical perspective that supports the evolution of instructional design in sports education.

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Ethical Statement

Informed consent was obtained from all participants prior to video recording and data collection. The researchers involved in this study have completed certified training in human research ethics.

Conflicts of Interest

The authors declare that they have no conflicts of interest in this work.

Data Availability Statement

Data are available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Termpetch Sookhanaphibarn: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft, writing—review & editing, visualization, supervision, and project administration.

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