

Digital-Intelligent Pedagogy in Physical Education: A Narrative Review of AI, Learning Analytics, Assessment and Equity

Tan Fang¹, Johansyah Lubis^{2*}, Samsudin³

¹⁻³Faculty of Sports and Health Sciences, Universitas Negeri Jakarta, Indonesia

Corresponding Author: Johansyah Lubis, Email: johansyah8886@yahoo.com

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ABSTRACT:

Physical education is increasingly being reconfigured by artificial intelligence, learning analytics, wearable devices, immersive media, and digitally mediated assessment. However, the field is still suspended between robust technology promises and disproportional pedagogical indications. In this narrative review, the authors reviewed the latest literature on digital-intelligent pedagogy in physical education, focusing on AI support for feedback, learning analytics, assessment, teacher mediation, and digital equity. The review considered primary empirical research published not earlier than 2021 and used recent reviews and methodology papers to put the gap into context, which supports the appraisal and contextualises the synthesis. Thematic analysis resulted in five themes: AI feedback has the potential to enhance motor learning by increasing practice time and presenting interpretable feedback; wearable and IoT analytics can help customise assessment but require high levels of acceptance and data quality; immersive and gamified design can enhance motivation but is not guaranteed to transferable competence; teacher mediation is the necessary condition to pedagogical value; and equity, privacy, and inclusion, is weaker than technical innovation. The review asserts that novelty must not be considered a criterion for judging digital-intelligent pedagogy. It's worth lies in its ability to enhance embodied learning, defend agency on the part of students, assist teachers, and curtail rather than intensify disparities in participation. This article adds a cohesive system of future PE studies and practices which link AI functionality, assessment literacy, teacher judgement, and inclusive access.

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Introduction

The traditional model of physical education (PE) has always been associated with data, even though these data were expressed as teacher observation, peer feedback, on-timed

performance, movement-corrective, and informal evaluations of effort. The only differences are the magnitude, rate, and transparency of data production. Recent developments in the concept of digital-intelligent technologies state that PE is the area

where artificial intelligence, the Internet of Things, big data, immersive media, and adaptive feedback are being integrated into new teaching and learning systems, instead of being treated as single tools (Zhong et al., 2025). The significance of this change is that PE is not a topic of interest solely in the context of physical activity. It is an educational environment in which students develop competency in movement, body confidence, health literacy, social engagement, and self-regulation. Thus, digital tools cannot be judged based on the criteria that they gather more information. They should be evaluated on the premise of whether they enhance embodied learning at the expense of the pupils being rendered as performance traces.

Recent reviews have shown guarded optimism. Bofill et al. (2025) identified that AI work in PE is still small but growing, with early studies showing promising results in the domains of video analytics, intelligent tutoring, the Internet of Things, and personalised feedback. This was also the case for Martín-Rodríguez and Madrigal-Cerezo (2025), who reported benefits to engagement, motor skill progress, and self-regulated learning across wearable, gamified, immersive, and AI-assisted practices. Nevertheless, an imbalance persists in these reviews. Numerous articles define technological affordance in general, and fewer present solid evidence on PE competences being taught to students at a deeper level, transferring and gaining more skills across contexts, and feeling more of the inclusive experience. The necessity of teacher training, as stressed by Wang and Wang (2024), was more practical as the question: can teachers be deployed to be professional data interpreters, or to be operators of systems planned, or are the systems predetermined?

This tension has been depicted in primary studies. Ma et al. (2025) concluded in an eight-week randomised trial that AI-based pose feedback enhanced Baduanjin learning time and better performance in comparison with a standard online format of PE. This is encouraging because online PE has, in most

cases, been unable to deliver corrective feedback. However, the same study revealed that the duration of learning was the main responsible factor, and not merely interest or self-direction, which would mean that AI operated by balancing practice opportunities as opposed to one AI creating more profound motivation automatically. Likewise, wearable and IoT literature demonstrates significant performance and assessment potential increase (Xu et al., 2024; Fu et al., 2021) yet demonstrates that student acceptance, infrastructure, and interpretation are central. Technology may elevate the requirements of making learning more visible, but this does not imply fairness and comprehension.

This finding is also in contrast to the higher education environment and school PE, as evidenced by the growing literature. Zhong et al. (2025) observed that most digital-intelligent PE research has been conducted in higher educational institutions, with younger students and those with disabilities being underexplored. This imbalance is important because the claims of equity that are attached to AI and learning analytics are most vulnerable when the least visible groups in the evidence base are the ones that are dominated. The exclusion of teachers and students in the development of systems that are considered beneficial in education contributes to alerts in human-centred learning analytics scholarship: when systems are developed without considering teachers or students, they may be met with mistrust, agency loss, and lack of impact on classroom realities (Alfredo et al., 2024). PE further complicates the matter because data about movement may be sensitive, embodied, comparative, and socially consequential.

This narrative review critically synthesises current primary evidence on AI, learning analytics, assessment, and equity in physical education and formulates an integrated set of digital-intelligent pedagogy that will place teacher mediation, embodied learning, and inclusive participation at the core of technology use.

Methods

The current narrative review was not a meta-analysis but a qualitative synthesis designed in a structured fashion because it was based on evidence with heterogeneous designs, interventions, outcome measures, and educational settings. A narrative approach was suitable as the review question concerned the pedagogical positioning of digital-intelligent tools in PE and not necessarily whether a pooled effect size was achieved by one intervention. Recent PRISMA recommendations on transparent review reporting (Page et al., 2021) informed the reporting process, with decision-making on appraisal based on the recent JBI critical appraisal principles of randomised and quasi-experimental evidence (Barker et al., 2023; Barker et al., 2024). The instruments were adopted to enhance clarity and judgement, and the systematic review was not exhaustive.

A search was conducted in open scholarly databases and platform publishers, such as PubMed, Springer, Frontiers, MDPI, Taylor and Francis, IEEE Xplore record pages, Google Scholar, and journal webpages. The search was limited to the years 2021-2025. The primary search terms were PE-related terms and technology- or pedagogy-related terms, such as physical education and artificial intelligence, physical education and learning analytics, physical education and wearables, physical education and assessment, physical education and virtual reality, and physical education and equity. This was done through backward and forward citation tracing based on recent PE technology reviews to determine which empirical studies were directly relevant to teaching, learning, assessment, or inclusion.

The eligible studies met four criteria. First, they discussed PE, sport pedagogy, learning movements, or PE teacher practice, not only focusing on elite performance. Second, they examined a digital-intelligent tool, such as AI feedback, wearable sensing, IoT analytics, immersive reality, data mining, speech recognition, digital platforms, or intelligence in

the assessment. Third, they cited empirical, applied, or design-based evidence by either learners, teachers, teaching systems, or classroom-based outcomes. Fourth, they should be published in English between 2021-2025. The exclusion criteria were studies that simply discussed the performance of engineering without educational context, studies that referred to PE in an overriding way, and studies that did not report outcomes concerning teaching, assessment, participation, or student learning.

Data were extracted using a matrix which includes author, year, country or context, where available, population, technology, design, main outcomes, pedagogical contribution, and limitation. Primary studies were prioritised in the thematic synthesis. The field was defined through recent reviews, gaps were defined, and the extent to which the key evidence supported or refuted the bigger assertions was identified. The thematic analysis was conducted in three stages. First, the repetitive concepts were coded, including real-time feedback, movement analytics, acceptance, motivation, teacher competence, assessment automation, and the digital divide. Second, these codes were placed in larger interpretive categories. Third, these categories were narrowed to themes based on a comparison of convergent and divergent results between the intervention, survey, system design, and analytics research.

Quality evaluation was performed narratively owing to the methodological diversity of the evidence base. Two types of studies (randomised and quasi-experimental) were read to compare the clarity of comparison groups, equivalence of the baseline and duration of intervention, validity of outcomes, and focus on mechanisms. Sampling, clarity of the scales, justification of the models, and the chance of self-reporting bias were presented in the survey studies. Reading system design studies were based on whether they described a pedagogical value that superseded technical feasibility. This review is significant because the literature tends to believe that digital adoption is intrinsically positive. The review thus critically synthesised

findings by determining whether each tool enhanced learning, assessment judgement, teacher practice, or equity, as well as where

evidence was preliminary, context-specific, or over-technology-driven.

Table 1. Search and selection framework

Review component	Decision used in this review	Justification
Review type	Structured narrative review	The evidence was too heterogeneous for meta-analysis, while the aim required an interpretive comparison of pedagogy, assessment, and equity.
Date range	2021 to 2025	The field has changed rapidly after the expansion of AI, wearable analytics, and post-pandemic blended PE.
Priority evidence	Primary empirical and applied studies	The thematic findings were grounded mainly in studies that reported learner, teacher, assessment, or system outcomes.
Supporting evidence	Recent reviews and methodological papers	Reviews framed the gap, and appraisal papers supported transparent judgement.
Main synthesis logic	Thematic comparison	Themes were generated by comparing repeated mechanisms, benefits, limits, and contextual conditions across studies.

Thematic Findings

Five themes were identified during the synthesis. There were no overwhelming data pointing towards how digital tools improve PE, regardless of the theme. Instead, evidence indicates that technologies play a role in learning when they alter the quality of feedback, promote meaningful practice, aid teacher judgement, or enhance responsive assessment. On the other hand, the tools became pedagogically thin when they were used as instruments of surveillance, scorers, and novelty-driven interaction with minimal learning rationale.

Theme 1. AI feedback strengthened movement learning when it extended the teacher feedback loop

The strongest data were from studies in which AI was related to a particular motor learning issue. Ma et al. (2025) employed pose recognition to overcome the limited availability of real-time feedback in the teaching of Baduanjin on-line. Relative to a MOOC-only format, the AI feedback condition led to higher levels of performance, fluency, interest, and self-directed learning. However, the mediation results make it difficult to have a strictly celebratory reading. The significant mechanism

was more learning time and interest, while self-directed learning was not an important mediator. This implies that AI did not merely inspire students with technological newness. This rendered practicality more ongoing, responsible, and supervised. Other research goes in the same direction, but with less pedagogical explanation. Ma and Tran-Nguyen (2024) suggested PETSAI-Ext as a PE teaching support system, and He et al. (2024) studied interstitial AI technology as a PE in higher learning establishments as a visual analysis-based interactive system. The technical feasibility of intelligent support is demonstrated in these studies, but a common question is raised: movement recognition can recognise form, but not necessarily describe fear, confidence, effort, cultural meaning, or tactical decision-making. In another study, Sang and Chen (2022) incorporated speech recognition that helped in human-computer interactive teaching of PE as an extension of the interface beyond the video. The comparison between the visual and voice-driven systems implies that intelligent PE feedback should be multimodal, yet it also suggests that multimodality makes teacher interpretation more necessary.

Theme 2. Learning analytics and wearable systems improved assessment visibility, but validity depended on acceptance and interpretation

The incentive for wearable and IoT research was that it bridged the gap between digital pedagogy and evaluation, as opposed to engagement only. Xu et al. (2024) discovered that wearable IoT devices were sensitive to the outcomes of PE in colleges, making user acceptance an essential mediator. This observation is significant because it disputes technological determinism. The sensors were not able to operate without the perception of usefulness and willingness to participate, as thought-out by students. Fu et al. (2021) emphasised the integration of wearable smart devices and Internet of Things technology into public physical education, whereas Fang (2022) investigated PE quality evaluation using wearable devices. All of these contributions lead to the argument that wearable analytics can support personalisation, yet only at a point when the data are trusted, meaningful, and acted upon. This reasoning was furthered by Lin et al. (2023), who gathered the results of electromyography and gyroscope data and showed that sensor feedback can be pedagogical when related to a particular skill model. The second strand employed data mining of physical health profiles and teaching management with the aid of algorithm modelling. Ji et al. (2024) have built the student physical health portraits by applying the principal component analysis and a better canopy k-means algorithm whereas Qiao (2024) analyzed the O2O blended teaching model and teaching effectiveness. These researchers showed that PE assessment could transcend single test scores toward multidimensional profiling. However, this comparison has its weaknesses. Algorithms imposed to generate portraits may be accurate but rely on a small combination of input values, even local conventions, and non-transparent judgments. Therefore, assessment literacy is necessary for learning analytics. Teachers should be aware of what the data can support, what cannot be demonstrated by the data, and when

human judgement is morally better than automated inference.

Theme 3. Immersive and gamified technologies increased engagement, but transfer to durable PE competence remained uncertain

Immersive technologies provide some of the best engagement benefits. Lee and Lee (2021) claimed positive outcomes of virtual reality soccer lessons on the attitudes of elementary students to PE lessons and the overall flow of classes. The study conducted by Fernández-Vazquez et al. (2024) revealed that virtual reality and the gamification effect, together with a practice teaching style, had an effect on motor skills and perceived effort. Liang et al. (2023) also found that augmented reality had the potential to enhance physical sustainable education learning behaviour and motivation. These findings align with motivation, flow, and situated practice, which play a role in PE as sometimes the students become inactive when the work becomes monotonous, when it is in front of the audience, or irrelevant to the interests of the students. However, participation cannot be equated with the depth of learning. Wang et al. (2022) revealed that supervised virtual reality training became effective in enhancing lower extremity strength in students with intellectual disabilities in eight weeks but failed in balance. This ambivalent finding is significant because it counters the premise that sophisticated physical competence is automatically generated in immersive environments. Immersive and gamified PE can be particularly helpful in repetition, confidence, and task visualisation, but the transfer of skills, long-term activity behaviour, and inclusive competence are not well supported. The imperative implication here is that immersive media should be developed based on a learning process rather than on stimulation per se.

Theme 4. Teacher mediation determined whether digital tools became pedagogy or administration

Evidence that concerned teachers revealed that not being a tool adoption problem was not the

only aspect of digital-intelligent pedagogy. In a survey of 217 PE teachers, Zhao et al. (2025) found that IT teaching predicted innovative teaching performance, and curriculum content and methods mediated the relationship between technology use, scoring, and management. This observation directly supports teacher-mediated reading. Technology was an issue; however, its issue was pedagogy. Provided that teachers redesigned tasks, content, and evaluation routines using digital tools, the tools facilitated innovation. As long as they were involved as mere administrative tools, the pedagogical virtues were reduced. This analysis is consistent with the evidence from a larger PE review. Both Martín-Rodríguez and Madrigal-Cerezo (2025) and Tohánean et al. (2025) emphasised professional development, infrastructure, and policy coherence as preconditions for the successful integration of technology. Wang and Wang (2024) further argued that training AI teachers should consider future PE teacher competence. The issue of teacher surveys and tool-centred studies contrasts informatively with each other. Studies on tools commonly focus on accuracy, efficiency, or engagement. Teacher studies focused on preparedness, infrastructure, and curriculum fit.

Theme 5. Equity and ethics remained underdeveloped compared with innovation claims

Equity was a recurring issue but seldom a well-tested outcome. According to the report by Zhong et al. (2025), the digital-intelligent PE

sequential studies have concentrated on and most of these studies are university-level and general-population studies, with few studies on younger learners or special populations. This knowledge gap undermines the popular argument that AI and analytics will democratise PE. When the primary focus of the studies is mainly research-intensive universities, then no confident generalisation of the evidence to any of the following areas can be made: public schools, rural schools, poorly funded programmes, or students with disabilities. The issue that Wang et al. (2022) provided an essential exception is that the study was conducted on adolescents with intellectual disability, yet the range of outcomes was also small, also demonstrating how much work remains to be done. This gap can be interpreted by human-centred learning analytics research. Alfredo et al. (2024) discovered that end-user engagement, security, trust and reliability remain defective throughout learning analytics and AI in education. This is critical for PE, as body size, fitness level, coordination challenges, and disability-related data can be revealed by movement data. Digital equity cannot be confined to access to devices. It consists of fair interpretation, protecting privacy, the possibility of opting out, the culture-responsive design of tasks, and not ranking them publicly. The literature is most effective when the way AI can be used to assist feedback is described. It is weak in its explanation of how students are dignified, agentic, and equal participants in data-intensive PE.

Table 2. Thematic synthesis of primary evidence

Theme	Key primary studies	Convergent evidence	Critical interpretation
AI feedback and movement recognition	Ma et al. (2025); Ma and Tran-Nguyen (2024); He et al. (2024); Sang and Chen (2022)	Real-time feedback, visual analysis, and speech interaction can improve practice support.	The strongest mechanism was extended practice and feedback availability, not automatic pedagogical transformation.
Wearable and IoT learning analytics	Xu et al. (2024); Fu et al. (2021); Fang (2022); Ji et al. (2024)	Sensors and analytics have made performance and physical health data more visible.	The assessment value depended on student acceptance, data validity, and teacher interpretation.

Immersive and gamified learning	Lee and Lee (2021); Fernández-Vázquez et al. (2024); Liang et al. (2023); Wang et al. (2022)	VR, AR, and gamification often support motivation, flow, and repeated practice.	Evidence for long-term transfer, balance, inclusive competence, and sustained activity was less consistent.
Teacher mediation	Zhao et al. (2025); Qiao (2024); Huang and Yu (2022); Wu et al. (2024)	Digital use contributes to innovation when linked to teaching methods, content, and blended design.	Teacher readiness and curricular alignment were more decisive than tool availability.
Equity, privacy and agency	Wang et al. (2022); Xu et al. (2024); Zhao et al. (2025)	Evidence touched on inclusion, acceptance, and infrastructure but rarely tested equity directly.	Future studies should consider equity as an outcome rather than a concluding statement.

Discussion

This indicates that digital-intelligent pedagogy in PE is viewed as more of a socio-technical practice than a category of technology. AI feedback, wearable analytics, immersive learning, and blended platforms failed to create value. To a larger extent, AI feedback was most appealing when it resolved a tangible issue in practice, such as the lack of actual corrective feedback in online skills acquisition (Ma et al., 2025). Wearables excel in the context of formative interpretation of movement, effort, and health measurements (Xu et al., 2024). Engagement and repetitive practice were strongest in immersive media (Fernández-Vázquez et al., 2024; Liang et al., 2023). IT in teacher formats proved to be the most powerful when it transformed practices and evaluation oversight (Zhao et al., 2025). These variations are important because the discipline tends to pronounce the entirety of digital interventions as one language of change. An extreme comparison also reveals that the most forceful arguments are not necessarily associated with the most recent tools. Certain immersive and wearable interventions were found to generate measurable outcomes, the impact of which was frequently confined by setting, duration, and outcome selection. Wang et al. (2022) reported improvements in strength but no balance improvement, whereas Ma et al. (2025) reported an increase in performance, which was largely mediated by the learning duration. Weakness is

not a result of these factors. They are useful as corrections against overstatements. They suggested that technologies correspond to certain PE outcomes. Pose recognition systems can be applied to visible movement forms, but less so in teamwork, creativity, or affective confidence. The intensity may be attained with a wearable device, but it is unlikely to be tactical appreciation or enjoyment. Assessment was also found to be a battleground in the review. Conventional PE testing has been faulted because of over-rusting performance standards, athletic performance, and social ranking. Digital analytics can intensify or alleviate this condition. On the one hand, data could facilitate more formative, individualised, and process-based feedback. Conversely, automated dashboards can promote focused measurements and latent bias. Li et al. (2024) and Ji et al. (2024) demonstrate that data mining and AI will be able to structure the complex evaluation, but the systems need to be transparent. Students might not know why they are rated in a particular manner, and teachers might find it hard to contest the results of algorithms without comprehensible criteria. Thus, innovative assessments should encompass interpretability and student discourse, as well as computational efficiency.

The most robust cross-cutting condition is teacher agency. The literature has continuously suggested that PE teachers require training beyond technical training. They require online

evaluation expertise, moral making, and the capability to incorporate analytics into lived work. Zhao et al. (2025) established that the methods and content of IT teaching mediated the relationship between IT teaching and assessment-management innovation. This is an essential conclusion as it places pedagogy between technology and outcome. It also questions institutional strategies that primarily emphasise equipment purchases. Sensors, applications, and VR headsets can be purchased by a school without the creation of digital intelligent pedagogy. On the other hand, a teacher who possesses modest tools can create significant learning when feedback, reflection, and inclusion are crafted. Equity is the least mature aspect of ESG. Latest reviews repeatedly agree on the advantages of access, ethics, and privacy, but primary studies seldom investigate whether disadvantaged students benefit equally (Bofill et al., 2025; Zhong et al., 2025). This is particularly concerning in PE, where information concerning the body may enforce comparison and stigma. Equity should be operationalised by hiring varied learners, effects of disability designs, privacy-conscious analytics, student voice, transparent interface, and contextual reporting of infrastructure. The discipline should also investigate how AI systems might favour certain forms of movement that are of different bodies, cultures, or sporting traditions. A digital-intelligent PE framework must therefore integrate four questions: What learning problem is being addressed? What data are being collected, and why? How are teachers using data pedagogically? Who may be excluded, exposed, or misclassified by the system?

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Conclusion and Implications

The findings of this narrative review indicate that the purposeful potential of digital-intelligent pedagogy in physical education is meaningful, but only when technology is subservient to learning. PE can be enhanced through AI feedback, learning analytics, wearable devices, and immersive environments to make movement more obvious, feedback timely, and practice more individual. However, this evidence is insufficient to make an overall statement that digital innovation will necessarily increase PE. The most plausible studies revealed circumscribed benefits relating to a particular mechanism, including the length of practice, better feedback, enhancement of engagement, or enhanced organisation of assessment. The overall lesson to PE teachers is that digital tools are not to be used as substitutes for professional judgement but to become an interpretive aid. Educators must choose when information is helpful, when it is deceptive, and how it can be translated into integrative movement activities. Institutions must invest in teacher development, privacy protection, available infrastructure, and redesigning the assessment system, just as they do in devices. To researchers, the shift is to outgrow the stage of feasibility and satisfaction studies to more solid longitudinal, comparative and equity based designs. Further studies are required to investigate the role of digital intelligent PE in enhancing durable competence and inclusive participation, confidence, health literacy, and lifetime participation. Students and teachers should also be engaged in field design to ensure that AI and analytics are responsible for human learning. Digital-intelligent pedagogy will prove useful not only because it renders PE more technological, but also because it can render PE more responsive, reflective, and just.

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