Inclusive and Adaptive Physical Education in the Post-Digital Era: A Narrative Review of AI-Assisted Differentiation, Universal Design and Participation for Diverse Learners

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HOW TO CITE:

Peng Yuxi, Yasep Seiakarnawijaya, Susilo (2026). Inclusive and Adaptive Physical Education in the Post-Digital Era: A Narrative Review of AI-Assisted Differentiation, Universal Design and Participation for Diverse Learners. International Journal of Special Education, 41(13s), 419-429

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ABSTRACT:

Inclusive physical education has taken a post-digital turn, where technology is not a secondary teaching resource but a constituent element of the daily ecology of lesson planning, feedback, assessment, and participation. This narrative review critically synthesises the current evidence on AI-assisted differentiation, universal design in learning, adaptive physical education, and digital participation in learning among diverse learners. To conduct the review, the authors focused on primary studies published between 2021 and 2026, whereas recent systematic and scoping reviews were used to introduce the evidence climate. A synthesis identified four themes. To begin with, technology was most inclusive when it enhanced teacher judgement and was not a substitute, since barriers to participation were typically pedagogical, social, infrastructural, and technical. Second, digital media and universal design assisted teachers in providing many representations, flexible paths of tasks, and alternative forms of expression, and the empirical foundation remained fractured and frequently based on small-scale validation or design experiments. Third, AI, augmented reality, virtual reality, and exergames fostered feedback, motivation, and motor-skill practice, but the improvements came unevenly with designs that focused more on novelty than on alignment to the curriculum. Fourth, inclusive digital PE necessitates ethical governance, available infrastructure, student voice, and peer mediation. Overall, the literature indicates that in the case of a larger system of embedded AI-assisted differentiation, aligned with learning outcomes, and managed by trained instructors, the system could support inclusive and adaptive PE. The primary value of the review is the creation of a pedagogical synthesis which links digital innovation with inclusion but does not view disability access, UDL, and AI-enabled personalisation as two distinct strands of research.

Keywords: inclusive physical education; adaptive physical education; universal design for learning; AI-assisted differentiation; augmented reality; participation

1. Introduction

Physical education (PE) is a key location of health, social belonging, and movement competence in all school environments, but it is also an environment where various learners can feel excluded. Neurodiverse learners, students with low confidence, neurodiverse students, and students with different movement histories regularly receive the same curriculum using the same equipment, space, pace, and assessment requirements. Recent inclusive PE scholarship has thus shifted from whether students can be included in normal lessons to how lessons can be designed to value student participation from the outset (Bertills & Björk, 2024; Fierro-Saldaña & Treviño-Villarreal, 2025). This change is significant since inclusion in PE is not just a question of physical presence. It is also related to perceived competence, access to tasks, peer recognition, fairness in assessment, and the opportunity to feel movement success.

This agenda is challenging in the post-digital era. PE research is becoming more evident through the use of digital tools, artificial intelligence (AI), augmented reality (AR), virtual reality (VR), mobile applications, and sensor-based feedback (Cui, 2025; Tohănean et al., 2025; Wang & Wang, 2024; Zhong et al., 2025). Such tools are frequently marketed as the path to personalisation because they can produce demonstrations, track performance, adjust difficulty, or provide instant feedback. Nevertheless, identical tools can recreate exclusion when they presuppose normative patterns of movement, costly equipment, sensitive information, or favour students who already have digital confidence. Reviews of AI and VR in inclusive education have also contended that access to technology does not necessarily translate into access to education (Chalkiadakis et al., 2024; Pagliara et al., 2024). However, a critical review of inclusive PE must go beyond merely stating whether digital tools are effective, to who, in what pedagogical conditions, and with what risks.

With the help of Universal Design of Learning (UDL), a bridge between adaptive PE and digital innovation can be created. UDL focuses on flexible interaction, various representations, and various actions and expressions. This may include visual illustrations, tactile feedback, progressive movement activities, peer-led stations, alternative success criteria, and available evaluation formats in PE (Haegele et al., 2024; López Ibáñez et al., 2023). However, UDL cannot be condensed into a list of accommodations. Recent literature cautions that the evidence of UDL in PE is less developed than its popularity in policy and that implementation requires teacher preparation, institutional, and contextual resources (Haegele et al., 2024; Lourenço et al., 2025). UDL can be expanded with the help of digital tools, but only when these tools can facilitate flexible pedagogy rather than introducing an additional inflexible layer to the lessons.

Recent (within five years) primary research offers a more subtle image than technology-optimistic reviews. For example, VR-based PE improved the physical fitness of elementary school students, and ICT-based exergames resulted in an increase in the chosen basic movement skills in children with developmental disabilities (Bae, 2023; Kwon et al., 2022). AR-PE among dyslexic students implied potential benefits due to visualisation and engagement, whereas the literature on teacher attitude and differentiation instruction indicated that including dyslexics remained a matter of professionalism, peer culture, and assessment modification (Mokmin et al., 2025; Suherman et al., 2026). The main issue the field is grappling with due to this contrast is that digital tools can contribute to more people having access to representation and feedback, and inclusive participation demands a pedagogical architecture that predicts learner variance before it breaks down. This narrative review aimed to provide a synthesis of the ways AI-assisted differentiation, universal design, and adaptive digital tools can assist in an inclusive PE design, differentiated instruction, and participation of diverse learners in the post-digital era.

2. Methods

The research design was a narrative review, as the topic spanned multiple bodies of literature with varying notions, procedures, and outcome measures. This manuscript would have been more appropriate as a systematic review with a simpler intervention and a more uniform outcome set. However, it attempts to consider evidence on inclusive PE, adaptive PE, UDL, AI-assisted differentiation, AR, VR, and digital participation. This systematic yet interpretive review ensured that primary empirical evidence had the opportunity was contrasted with conceptual and review-based assertions. This method was appropriate because inclusive digital PE is a new area where pedagogical mechanisms are more critical than effect sizes.

Between the drafting stage and June 2026, searches were performed in Scopus, Web of Science, ERIC, PubMed, Frontiers, MDPI, and Google Scholar. The key search terms were PE words and technology terms: inclusive physical education, adaptive physical education, universal design, AND physical education, AI, AND physical education, augmented reality, AND school physical education, and differentiated instruction. Additionally, recent reviews on AI in PE, technology-infused physical activity, UDL in PE, and inclusive education through technology were also citation chased. This was done to minimise the possibility of omitting any pertinent primary studies that were catalogued under special education, educational technology, or public health but not under PE-specific ones.

Included studies had to be published between 2021 and 2026, focus on PE, physical activity at school, adapted physical activity, or similar movement learning training, and had to take into consider at least one of the following factors: disability inclusion, diverse students, UDL, differentiated instruction, AI-assisted feedback, AR, VR, exergames, or digital accessibility. The thematic results were prioritised based on primary studies. Reviews were excluded unless they explained the evidence status, there were gaps or they offered theoretical context. The studies were eliminated when they emphasized only elite sport analytics or clinical rehabilitation and non-educational movement content, non-clinical general online learning, and non-authentic acceptance of technology without any plausible connection to inclusive PE practice.

The data were imported into a tabular format that included author, year, learner group, technology or pedagogical design, research design, inclusive mechanism, main contribution, and limitation. Thematic synthesis was performed in step three. First, descriptively coded evidence was organised into feedback, representation, task adaptation, motivation, assessment, teacher competency, peer participation, and infrastructure ethics. Second, the comparison of codes among primary studies helped determine which mechanisms and contradictions occurred repeatedly. Third, the themes were refined against the review question and current reviews to prevent overgeneralisation of the individual empirical studies. Hence, this was not a meta-analysis. It addressed the quality of evidence by means of relevance, methodological transparency, population fit, and transferability. This was suitable, as sample sizes, disability populations, technologies, and outcomes differed immensely across the studies.

This review had two limitations. First, only English-language and readily available sources were considered, which may have underrepresented local research in other languages. Second, there was an unequal evidence base for the studies. Certain technologies, such as VR or exergames, have measurable movement results, whereas AI-assisted differentiation in PE is more frequently discussed in the context of emerging studies, teacher attitudes, or the larger scope of inclusive education research. To cope with this shortcoming, the synthesis distinguishes between more robust primary-study evidence and more tentative implications.

3. Thematic Findings and Critical Discussion

The thematic synthesis revealed that there can be no simple question of whether technology enhances performance in evaluating inclusive digital PE. A better question is whether technology alters the conditions of participation of learners who are conventionally marginalised by standardised movement tasks. In the literature, the best designs possess three characteristics: they reveal learning in a multirepresentational way, permit variability of pathways of investigation to the same movement product, and maintain teacher or learner-learner mediation. Weak designs integrated inclusion as personal redress, with the learner needing to adjust to the tool and not the opposite.

3.1 Primary Studies Included in the Thematic Synthesis

The largest contributions of the thematic synthesis are summarised in Table 1 on their basis. The evidence base was put into perspective using review papers, but the thematic claims were derived mostly from studies that analysed learners, teachers, programmes, or technology-assisted PE practice.

Table 1. Primary studies informing the thematic synthesis

Study	Design	Context or learners	Inclusive contribution	Main limitation
Bertills & Björk (2024)	Qualitative teacher-view study in regular PE	Students with disability in secondary PE	Participation depended on planning, relational knowledge, support, and inclusive class organisation.	Did not test a specific digital intervention.
Fierro-Saldaña & Treviño-Villarreal (2025)	Case study using interviews, focus groups and observation	Elementary schools including students with disabilities	Inclusive PE requires coherent links among teacher flexibility, infrastructure, management, and community communication.	Context-specific evidence from three schools.
Suherman et al. (2026)	Mixed-methods study	Indonesian primary PE teachers and students	Differentiation requires teacher education, assessment guidance, and collaborative professional support.	This study focused on primary PE in a national setting.
López Ibáñez et al. (2023)	Design and expert-validation study	Primary PE and learners with intellectual functional diversity	UDL and ICT were used to design multiple representations and adaptable participation routes for the learning process.	The validation evidence was stronger than the implementation evidence.
Sapre et al. (2025)	Rapid-cycle adaptation	Neurodivergent children using	AI and UDL support safer, clearer, and more	Home context may not fully transfer to

Study	Design	Context or learners	Inclusive contribution	Main limitation
	project	home-based PA	accessible physical activity content.	school PE.
Kwon et al. (2022)	Development and intervention study	Children with developmental disabilities	ICT exergames improved selected fundamental motor skills and the standing long jump.	Limited range of skills and disability groups.
Bae (2023)	Quasi-experimental PE intervention	Korean elementary school students	VR-based PE improved physical fitness indicators compared to the control conditions.	It was not designed specifically for disability inclusion.
Mokmin & Ridzuan (2022)	Empirical study on immersive technologies	Malaysian students with learning disabilities	Immersive PE tools were valued when they addressed concentration, confidence, and flexible learning needs.	The evidence base remains exploratory.
Mokmin et al. (2025)	Teacher and student perspective study	Dyslexic students in PE	AR supported visual access, engagement, and comprehension of PE tasks.	Stronger evidence is needed on long-term motor and social outcomes.
Rakha (2026)	Experimental higher-education PE study	University handball beginners	ChatGPT-supported reciprocal teaching improved skill acquisition and attitude.	Indirect relevance to school disability inclusion:
Xie et al. (2025)	Sequential explanatory mixed-methods study	University table-tennis learners	Multimedia, VR, AR, and AI have created a structured model for performance and fitness improvement.	A technology-rich university context may not reflect school constraints.
Bertills et al. (2021)	Quantitative study	Students with and without disabilities	Self-efficacy and aptitude for participation were linked to functioning and achievement, supporting a participation-focused assessment.	Technology was not the primary intervention.

3.2 Technology Did Not Replace Inclusive Pedagogy

The initial theme was that inclusion has been a pedagogical (and systemic) problem prior to becoming a technological one. Bertills and Björk (2024) demonstrated that students with disabilities were perceived to be dependent on participation by PE teachers in terms of planning, relational knowledge, support structures, and organisation of classes. Likewise, Fierro-Saldaña and Treviño-Villarreal (2025) observed that the effectiveness of flexible teaching approaches was impaired in the case of poor school infrastructure, communication channels, and cohesion of schools owned by poor institutions. These studies contrast with technology-based studies which frame digital tools as straightforward solutions. The comparison was significant. It can be an AR application, AI-generated feedback, or a wearable display used by a teacher. However, the student can be excluded in case of a task objective that cannot be compromised, or others assume that his/her adaptation is the manifestation of incompetence This was supported by recent evidence on teacher competence and differentiated instruction (Ben Rakaa et al., 2024). Suherman et al., (2026) discovered that Indonesian primary PE teachers required contextual relevant training, differentiation on assessment and collective professional direction. This observation is in line with Mihajlović and Meier (2023), who highlighted that it is the activity modification as a learning maximisation process, as opposed to the simplification of tasks. The difference between these studies and more device-oriented digital PE research is that a decision made by teachers led to inclusion, but not automation per se. AI can suggest the level of tasks, visual clues, or evaluation options; however, AI cannot comprehend classroom ecology without teachers critically interpreting these suggestions.

3.3 UDL Turned Digital Tools into Anticipatory Differentiation

The second theme dealt with UDL as a design logic of differentiation in the digital. UDL was useful in transforming adaptation as an unplanned reaction to an anticipatory design principle. Haegele et al. (2024) argued that despite the conceptual potential of UDL in PE, the approach still requires critical consideration due to limited empirical evidence. This warning contrasts positive pronouncements in more general inclusive technology upheavals, where AI and VR are often said to automatically individualise learning (Chalkiadakis et al., 2024; Melo-López et al., 2025). Personalisation should encompass embodied, spatial, and social dimensions in PE. A video prompt can enhance representation, but would not necessarily enable a wheelchair user, a student with visual impairments, or an anxious student to be included on an equal footing unless the equipment, rules, grouping, and assessment are redesigned. Evidence of the intervention design was a more practical avenue. López Ibáñez et al. (2023) developed and validated a PE intervention based on ICT and UDL when working with learners who are intellectually functionally diverse. Sapre et al. (2025) adjusted the InPACT at Home programme to neurodivergent children by integrating AI-assisted adaptation with UDL concepts. However, these reports were not the same. The former aimed at the professional legitimisation of an educational program, and the latter involved fast-cycle adaptation to render home-based physical activity more accessible and safe. They all contributed to the idea that digital was seen as a design. The intervention was not just a tool in itself. Rather, the intervention was in terms of available representations, modifiable tasks, explicit routines, and a focus on learner variability.

3.4 AI, AR, VR and Exergames Supported Access but Needed Curriculum Alignment

The third theme was that immersive and intelligent tools facilitated participation by offering feedback and representation that are not easily offered at scale by teachers. According to the findings of a study conducted by Bae (2023), a VR-based PE program was more efficient in promoting the physical fitness of elementary students, which implies that an

environment that encourages immersive practices can enhance the chances of engagement and an opportunity to move in an organised manner. Kwon et al. (2022) reported positive effects on selected fundamental movement skills and standing long jump in children with developmental disabilities under the influence of an ICT-based exergame. These results are more robust than strictly conceptual statements because they quantify the movement results. However, their constraints are also important. Controlled settings were common in VR and exergame studies, and the tasks chosen and relatively brief windows over the intervention, so it is not clear whether the results of these studies can be transferred to a busy PE classroom.

Another level was added to the AR studies. Mokmin and Ridzuan (2022) created awareness of the necessity of immersive technologies that were aligned to the concentration, confidence, and flexible-learning requirements of Malaysian students with learning disabilities. Mokmin and Rassy's (2022) review of AR applications among students with learning disabilities in PE reported that there were still limited empirical applications of AR. Mokmin et al. (2025) assessed AR in PE among dyslexic students subsequently, using teacher and student ratings and demonstrated that AR would facilitate visual access and involvement. These studies combined indicate movement, although they reveal an empty place. AR tends to be the most powerful visualisation and motivation, and inclusive PE involves transfer to motor competence, social participation, and assessment fairness.

The AI-assisted feedback generated presented some mixed implications to a similar degree. Rakha (2026) found that reciprocal teaching assisted by ChatGPT enhanced the development of handball skills and student attitudes among university beginners, and Alecu and Onea (2026) explored the use of generative AI and technology acceptance in PE classes. Xie et al. (2025) suggested and tried a multimedia inbuilt VR, AR, and AI-combined digital table-tennis model. These research undertakings can be beneficial because they demonstrate AI as a way to enhance feedback integrity and student interaction. However, they were not disability-inclusion studies, and the majority were in higher education. Their impact on inclusive PE in schools was indirect. They demonstrated the ability of AI to provide scaffolding feedback, but not that AI can independently distinguish PE in different learners.

3.5 Assessment, Ethics and Participation Governance

The fourth theme was ethics, assessment, and participation governance. Data on bodies, quality of movement, heart rate, attendance, confidence, and occasional disability-related adaptation are digitally produced by Digital PE. Surveys of AI in inclusive education have cautioned that bias, privacy, and accessibility must be design considerations and not afterthoughts (Navas-Bonilla et al., 2025; Pagliara et al., 2024). This is particularly relevant in PE, as an easy transition towards ranking data can occur. Movement-analysis tools can assist an individual learner to perceive technique but can also enhance comparison when scores are used by teachers without judgement on any contextual basis.

Thus, evaluation was one of the critical lines concerning the inclusion and exclusion. Similar to formal assessment, formative assessment can be assisted using digital tools, which display progress, provide alternative demonstrations of learning, and have students demonstrate competence through video, voice, peer explanation, or modified motion. However, when AI-driven criteria set a unique standard for the correct body movement, the evaluation process becomes problematic. The most compelling evidence lies in assessment literacy rather than automated scoring. Teachers had to know when a digital measure would be helpful, when it was being used in a disability-biased way, and when student voice must outweigh tool outputs. This observation links UDL to adaptive PE, as both systems necessitate adaptable learning findings.

The last contrast was regarding access. Technology-enhanced school physical activity review articles have stated that technology can encourage physical activity as long as interventions are appropriately planned (Ha et al., 2025). However, inclusive PE presents a more challenging standard. However, availability does not necessarily imply access. It consists of the cost of equipment, sensory availability of interfaces, compatibility with assistive devices, teacher training, peer acceptance, and family or school support. The point of the post-digital challenge is not to introduce more technology in PE but to create a more inclusive system of participation with regard to the technologies being selected.

Table 2. Practical synthesis of UDL mechanisms and digital supports

UDL or inclusion mechanism	Digital support	Likely inclusive value	Risk to manage
Multiple representation	AR overlays, video modelling, AI-generated cue cards, audio prompts	Supports dyslexic learners, neurodivergent learners and students who struggle with verbal-only instruction	Can overload learners if visuals are complex or poorly sequenced
Flexible action and expression	Tiered tasks, exergame difficulty settings, alternative movement demonstrations	Allows learners to show competence through adapted movement pathways	May become segregated if alternative tasks are not socially integrated
Feedback and self-regulation	AI prompts, sensor feedback, peer-feedback templates, video replay	Improves immediacy and consistency of formative assessment	Automated standards may misread disability-related movement differences
Engagement and motivation	VR games, AR challenges, choice boards, gamified progress feedback	Can reduce fear of failure and increase repeated practice	Novelty effects may fade without curricular meaning
Participation governance	Student consent routines, data-minimisation rules, teacher review of AI outputs	Protects dignity, privacy and fairness in inclusive PE	Often absent from intervention reports

4. Proposed Pedagogical Direction

According to the synthesis, an inclusive AI-assisted PE model should start with learner variability rather than the choice of tools. Participation barriers were identified by teachers at the engagement, representation, action, and assessment levels. Only in cases where a particular barrier was addressed would they choose digital tools. For example, AR may aid visual representation in the summary of a student struggling to read in written form, VR may aid in having a low-cost practice area, an exergame may help practice the basic moves repeatedly, and AI may assist in creating differentiated cue cards or peer-feedback prompts. Every usage would be subject to review by the teachers, since digital recommendations can be inaccurate, culturally insensitive, or unsuitable for the physical capacity of the learner.

A change between accommodation and co-design is also a prerequisite for this model. Decisions regarding the preferred types of feedback, the kinds of adaptations that are not embarrassing, and the type of data that should (or should not be gathered) should involve

students. Technology use should not isolate the learner, with peer roles planned accordingly. When a lesson is well designed, adaptation in the lesson is normalised, and choice, challenge, and feedback are experienced by all students. Students with extra needs are given a separate digital activity that diminishes the feeling of belonging in a weak lesson. This difference is the reason why the same tool may be inclusive in one school and exclusive in another. In terms of curriculum design, digital differentiation must be overlaid on unit objectives and implemented. A teacher might design a single motor outcome, two or three pathways for a task, multiple cue formats, and more than one artefact for assessment. AI would then be able to help by generating differentiated prompts, and the teacher would be able to check the accuracy, cultural fit, and safety. This process will not make technology an add-on but will tie digital inclusion to the general PE curriculum. It also enables schools with restricted resources to concentrate on straightforward tools, such as video modelling or audio prompts, before investing in costly immersive tools.

5. Conclusion and Implications

Making post-digital PE inclusive and adaptive cannot be interpreted as merely incorporating AI, AR, VR, or wearable devices into lessons. This can be interpreted as the redesign of the conditions of participation to such an extent that movement, feedback, peers, and assessment become accessible and available to diverse learners in a manner that is challenging, meaningful, and dignified. The evidence discussed in this post indicates that digital tools may enhance representation, motivation, and feedback, especially when tasks are not fixed and are somewhat rich in visuals. It also demonstrates that technological aspects are not the only solution to addressing social and institutional barriers that continue to form the fabric of exclusion in PE. The primary implication of this practice is that AI-assisted differentiation should be applied by teachers within the framework of universal design. Teacher judgement should not be substituted with digital tools. Schools should invest in professional learning that connects inclusion, assessment literacy, digital ethics, and adaptive task design. Technology adoption should not be a one-size-fits-all approach by curriculum leaders, rather than developing zigzag lesson patterns enabling more than one path to success. Policymakers and institutions should also address infrastructure, affordability, and data protection to ensure that inclusive digital PE is not distributed in well-resourced environments.Future research should not only be directed towards short-term novelty investigations but also look into long-term participation, skill transfer, student voice, and equity results. Further studies are necessary involving learners with other disabilities, in traditional school PE settings and in resource-poor environments. A fully automated PE is not the most promising direction, and well-mediated digital pedagogy is where AI and immersive tools assist teachers in creating a richer, fairer, and more responsive movement learning interaction.

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