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Physical literacy in primary physical education: A systematic review of game-centred, outdoor, and digitally supported pedagogy

Alfabetización física en educación física primaria: una revisión sistemática de pedagogías centradas en el juego, al aire libre y apoyadas digitalmente

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Abstract
Primary physical education (PE) is an important context for developing physical literacy (PL), which integrates motivation, confidence, physical competence, knowledge, and understanding to support lifelong engagement in physical activity. This systematic review synthesized evidence published from 2020 to 2025 on pedagogical models, design principles, and implementation conditions associated with PL outcomes in primary PE. Using a PRISMA-informed method, studies from Scopus and Web of Science were screened, and 23 articles were included. Four themes emerged. First, hybrid pedagogical models, including game-centred approaches combined with Sport Education, TGfU, or Cooperative Learning, supported enjoyment, tactical learning, and social development. Second, autonomy support, inclusive differentiation, formative assessment, representative tasks, and progressive complexity were the most consistent design principles. Third, the more consistent evidence indicated improvements in competence-related outcomes, including fitness and skill development, while validated game-based observation strengthened authentic assessment. Fourth, teacher capacity, assessment coherence, facilities, equity, and safety culture influenced implementation and transferability. However, studies that explicitly integrated digital scaffolding, outdoor learning, and game-centred pedagogy within one primary PE design remained limited. The review concludes that digital tools and outdoor contexts should function as purposeful pedagogical supports rather than isolated additions to movement-rich, inclusive, and safely managed game-based learning.
Keywords: physical literacy; primary physical education; game-centred pedagogy; outdoor learning; digital scaffolding.

Resumen
La educación física (EF) en la escuela primaria constituye un contexto relevante para el desarrollo de la alfabetización física (AF), entendida como la integración de la motivación, la confianza, la competencia física, el conocimiento y la comprensión para favorecer la participación en actividad física a lo largo de la vida. Esta revisión sistemática sintetizó evidencia publicada entre 2020 y 2025 sobre modelos pedagógicos, principios de diseño y condiciones de implementación asociados con resultados de AF en la EF primaria. Mediante un método informado por PRISMA, se examinaron estudios indexados en Scopus y Web of Science, incluyéndose finalmente 23 artículos. Surgieron cuatro temas. Primero, los modelos pedagógicos híbridos, incluidos los enfoques centrados en el juego combinados con Sport Education, TGfU o Cooperative Learning, favorecieron el disfrute, el aprendizaje táctico y el desarrollo social. Segundo, el apoyo a la autonomía, la diferenciación inclusiva, la evaluación formativa, las tareas representativas y la complejidad progresiva fueron los principios de diseño más consistentes. Tercero, la evidencia más consistente indicó mejoras en resultados vinculados con la competencia, incluidas la condición física y las habilidades, mientras que la observación validada basada en el juego fortaleció la evaluación auténtica. Cuarto, la capacidad docente, la coherencia evaluativa, las instalaciones, la equidad y la cultura de seguridad influyeron en la implementación y la transferibilidad. Sin embargo, los estudios que integraron explícitamente andamiaje digital, aprendizaje al aire libre y pedagogía centrada en el juego en un diseño unificado de EF primaria fueron limitados. La revisión concluye que las herramientas digitales y los contextos al aire libre deben

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funcionar como apoyos pedagógicos intencionados, no como añadidos aislados al aprendizaje basado en juegos, rico en movimiento, inclusivo y seguro.

Palabras clave: alfabetización física; educación física primaria; pedagogía centrada en el juego; aprendizaje al aire libre; andamiaje digital.

Introduction

Physical education (PE) in primary schools is increasingly viewed as a key setting for developing physical literacy (PL), commonly defined as "the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life" (Blain et al., 2022; Carl et al., 2023; Lubans et al., 2022). Recent scholarship has strengthened this holistic framing by treating PL as a pathway to sustained physical activity and wellbeing across the lifespan (Barratt et al., 2024; Fang et al., 2025; Y. Liu & Chen, 2020). In primary PE, PL is usually understood through interrelated domains—physical competence, motivation/confidence, knowledge/understanding, and participation—so effective learning design must support physical, cognitive, affective, and social development together (Hadier et al., 2024). Although PL is gaining policy and practice attention, the central problem is that many schools still lack clear pedagogical guidance for translating PL into teachable, assessable, inclusive, and context-sensitive PE practice (Carl et al., 2023). This problem is particularly important in primary education, where children require developmentally appropriate learning tasks, supportive motivation climates, equitable participation opportunities, and safe movement environments.

The first research strand concerns game-based pedagogy, including Teaching Games for Understanding (TGfU), Game Sense, Sport Education, and hybrid game-centred models, which have been widely discussed as approaches for promoting tactical understanding, decision making, enjoyment, and social learning in PE (Gil-Arias et al., 2021; Pan et al., 2023; Zhang et al., 2024). These approaches are promising because they can support autonomy, competence, and relatedness, which are central mechanisms for motivation, confidence, and sustained participation within PL (Blain et al., 2022). In contrast to isolated technical drills, game-based approaches allow children to develop tactical understanding, decision making, cooperation, and movement competence through modified and meaningful play situations. Related evidence also suggests that children's

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PL benefits from structured and supportive learning environments, a logic consistent with well-designed game-based PE settings (Fang et al., 2025; Santos-Miranda et al., 2025). However, evidence linking game-based pedagogy to PL development in primary PE remains dispersed across different pedagogical models, outcome measures, and implementation contexts. Therefore, the field still lacks consolidated guidance on which model configurations and design principles most consistently support PL domains, especially when game-based learning is connected with outdoor environments and digital scaffolds (Mo et al., 2024; Teraoka et al., 2021; Zhang et al., 2024).

The second research strand concerns outdoor learning and adventure-based education. In PE, these contexts are often valued because they provide novel, movement-rich, and socially interactive experiences. Reviews of outdoor and adventure education in K–12 PE consistently report social and emotional learning benefits, such as cooperation, responsibility, and social skills (Dyson et al., 2020; Neville et al., 2022; Robinson et al., 2021), although these outcomes are often inferred rather than measured with validated frameworks (Dyson et al., 2020). Outdoor contexts also strengthen engagement by offering authentic challenges, environmental variability, and contextual novelty, which can expand children's opportunities to explore, adapt, collaborate, and solve movement problems (Falzon & Conrad, 2023; Neville et al., 2022; Richards et al., 2023). Evidence from adjacent school subjects further suggests that technology-supported outdoor learning can improve learning performance and engagement when digital tools are used to guide exploration, structure tasks, and support reflection (Barbosa & Vale, 2023; Jhang et al., 2025; Lieberoth et al., 2025). For example, augmented reality outdoor learning has shown positive effects on performance, and mobile outdoor trails have been linked to persistence, collaboration, and cognitive and affective engagement (Barbosa & Vale, 2023). Although this adjacent evidence is not specific to PE, it helps explain how digital tools support orientation, feedback, collaboration, and reflection in outdoor learning. These mechanisms are relevant to PL because they align with autonomy support, peer interaction, and meaningful participation as key conditions for motivation, confidence, competence development, and sustained physical activity engagement (Barratt et al., 2024; Blain et al., 2022; Carl et al., 2023).

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The third research strand concerns blended, hybrid, and flipped learning. This strand is included because digital learning in PE is most relevant when it supports preparation, feedback, reflection, assessment, or access without replacing movement-rich lesson time (Centeio et al., 2021; Sargent & Calderón, 2021; Syah et al., 2022). Blended learning generally combines face-to-face and technology-mediated instruction, while hybrid learning is sometimes treated as a closely related or more specific variant (Kirby et al., 2025; Saichaie, 2020). Flipped learning moves direct instruction to pre-class activities so that lesson time can be used for active and collaborative learning (Østerlie et al., 2022). In PE, this often means that students access technique or tactical content before class and then use lesson time for movement practice, games, and cooperative tasks (J. Wang et al., 2023). Design work has also suggested that model-based practice and PL can be integrated within a Hybrid Learning Space for PE (Syah et al., 2022). Across studies, flipped or blended PE has been associated with outcomes relevant to PL, including motivation, self-efficacy, learning satisfaction, MVPA, reduced sedentary time, some gains in technique or knowledge, and social or emotional benefits, although physical fitness findings are mixed and outcome definitions remain inconsistent (Centeio et al., 2021; Ghorbel et al., 2024; C. Wang, 2023; Wu et al., 2025; Yip et al., 2023). Thus, the educational value of digital learning in PE depends less on the presence of technology itself and more on whether technology strengthens movement-rich, socially interactive, and pedagogically coherent lessons.

Despite progress in these three strands, their deliberate integration remains underdeveloped in primary PE. Existing evidence is often conceptual, context specific, or shaped by pandemic delivery constraints rather than by intentional design and evaluation. A persistent tension is that PE is commonly taught through movement-rich outdoor activity, whereas digital learning is sometimes seen as peripheral or even incompatible with the subject's practical nature (Cumal, 2025; Syah et al., 2022). This review addresses that tension through the concept of digitally scaffolded outdoor game-centred pedagogy, where technology primarily supports preparation, feedback, reflection, and assessment while core learning remains movement-rich and game based in authentic, often outdoor, contexts (Blain et al., 2022; Sargent & Calderón, 2021; Syah et al., 2022). In this review, the term "digitally scaffolded outdoor game-centred pedagogy" is used as

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an analytical synthesis concept rather than as a fully established intervention category. It refers to PE designs in which game-centred learning remains the core pedagogical approach, outdoor environments provide authentic and variable movement affordances, and digital tools support preparation, cueing, feedback, reflection, or assessment. This clarification is important because the review does not assume that all included studies explicitly combine all three components; instead, it examines direct, partial, and supporting evidence relevant to this emerging pedagogical configuration.

Within game-based PE, hybrid pedagogical models—especially Sport Education Model (SEM)–TGfU combinations—have attracted increasing attention. Reviews describe SEM–TGfU as a mainstream hybrid model associated with positive effects on motivation, enjoyment, game performance, and social learning (Zhang et al., 2024). Related empirical and review evidence also suggests that hybrid TGfU–Sport Education designs can support self-determined motivation, responsibility, enjoyment, and game performance (Gil-Arias et al., 2021; Pan et al., 2023; Zhang et al., 2024). However, outdoor learning is rarely treated as an explicit design feature in these hybrids, and technology integration has often been described as substitutive rather than transformative (Sargent & Calderón, 2021). Pandemic-era blended PE research also highlighted continuing problems related to access, participation, and meeting physical activity needs, showing that technology-supported delivery alone does not ensure coherent PE design (Centeio et al., 2021). Consequently, the key problem is not whether PE uses games, outdoor spaces, or digital tools separately, but how these components are aligned with learning intentions, teacher facilitation, assessment routines, equity, and safety.

Several gaps justify a systematic review of digitally scaffolded outdoor game-centred pedagogy for PL in primary PE (Carl et al., 2023; Sargent & Calderón, 2021; Østerlie et al., 2022; Zhang et al., 2024). First, few empirical studies intentionally combine outdoor learning, technology-supported delivery, and game-centred pedagogy within a unified primary PE design while examining outcomes across PL domains. Second, primary-specific evidence remains limited, including in the flipped-learning literature (Moorhouse & Wong, 2021; Rusnilawati et al., 2023), and PE-specific flipped learning reviews also show variability in outcome definitions, intervention designs, and reporting practices (Østerlie et al., 2022; Wu et al., 2025; Yip et al., 2023). Third, fidelity

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concerns already identified in hybrid pedagogical models—such as coherence, teacher competence, and model integration—become even more important in multi-component designs (Zhang et al., 2024). Fourth, outcome measurement remains inconsistent because PE studies use different meanings of "learning," which weakens comparability and synthesis (Østerlie et al., 2022). Taken together, these gaps indicate that current evidence is stronger for individual or partial components—such as game-centred pedagogy, hybrid models, outdoor learning, or technology-supported PE—than for their explicit three-way integration in primary PE. A systematic synthesis is therefore needed to clarify what is directly supported by evidence, what is only partially supported, and what remains an agenda for future research.

The broader literature also identifies recurring implementation barriers, including technology access and infrastructure, teacher readiness and professional development needs, limited curriculum time, participation and equity challenges in online components, and additional supervision or risk-management demands in outdoor settings (Beddoes & Sazama, 2024; H. Liu et al., 2022; Short et al., 2021). These barriers are especially relevant in primary PE because facility quality, rural–urban differences, socioeconomic inequalities, and restrictive safety cultures can shape children's access to meaningful and active participation (Almagor et al., 2021; Jerebine et al., 2022; Torkos & Egerău, 2020; Tyler et al., 2020; Xia et al., 2022). At the same time, several enablers appear repeatedly, including leadership support, resourcing, teacher professional learning communities, established game-based and models-based frameworks, and motivationally supportive structures aligned with self-determination theory (J. Wang et al., 2025; Yang et al., 2025). Together, these barriers and enablers suggest that teacher capacity, equity conditions, and safety cultures are likely to shape whether digitally scaffolded outdoor game-centred designs can be implemented with fidelity. For this reason, teacher capacity, equity, and safety are treated in this review as central implementation conditions rather than peripheral concerns.

In response to these gaps, this systematic review synthesizes peer-reviewed journal articles published between 2020 and 2025 in Education, Sport Science, and Social Sciences that focus on primary contexts. Although the Introduction draws on selected conceptual and definitional sources to frame PL and PE pedagogy, only studies published

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within the 2020–2025 eligibility window are treated as included evidence in the synthesis. The review distinguishes direct, partial, and supporting evidence because prior literature indicates that PE studies often vary in design coherence, intervention fidelity, outcome measurement, and technology integration (Sargent & Calderón, 2021; Teraoka et al., 2021; Østerlie et al., 2022; Zhang et al., 2024). The review aims to (i) identify pedagogical models used in digitally scaffolded outdoor game-centred pedagogy in primary PE, (ii) extract design principles and implementation patterns that may support PL domains, and (iii) evaluate reported effects on PL and closely related outcomes such as engagement, enjoyment or motivation, decision making or tactical understanding, and physical activity or competence. Because this is a systematic review rather than an experimental study, the synthesis is guided by research questions rather than by a hypothesis. Accordingly, the review addresses four research questions:

1. RQ1: What pedagogical models underpin digitally scaffolded outdoor game-centred pedagogy in primary PE (e.g., TGfU, model hybrids, models-based practice)?
2. RQ2: What design principles and design features are reported (outdoor task structures, digital scaffolds, gamification mechanics, assessment coherence and feasibility, teacher facilitation)?
3. RQ3: What effects are reported on physical literacy and related outcomes (motivation, engagement, decision making/tactical understanding, physical activity/competence)?
4. RQ4: Which contextual and implementation factors (teacher capacity, space and facilities, access, equity conditions, and safety cultures) moderate effectiveness?

Methods

Review design and reporting standard

This study used a systematic literature review guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The study design was a systematic review of peer-reviewed journal articles, not a quantitative intervention study with primary data collection. Therefore, the unit of analysis was the published study, while the target educational population was primary school children aged approximately 6–12 years and/or primary PE teachers. A PRISMA-aligned workflow was selected to

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support transparent identification, screening, eligibility assessment, and reporting of evidence in a heterogeneous field spanning outdoor learning, technology-supported delivery, and game-centred pedagogy in primary physical education (PE) (Mo et al., 2024; Teraoka et al., 2021). The review protocol was not prospectively registered; however, the eligibility criteria, extraction fields, appraisal criteria, and synthesis dimensions were defined before full-text coding to strengthen procedural transparency.

Information sources and search strategy

Searches were conducted in Scopus and Web of Science (WoS), two databases widely used in PE pedagogy reviews because they provide broad interdisciplinary coverage and strong journal indexing (Wiklander et al., 2023). Search strings combined Boolean operators, truncation where appropriate, and title/abstract/keyword field restrictions (Neville et al., 2022). Four keyword clusters were used: (1) PE context ("physical education", "school PE", "primary school", "elementary school"); (2) outdoor learning ("outdoor education", "outdoor learning", "learning outside the classroom", "adventure education", "nature-based learning", "green schoolyards") (Carl et al., 2025; Falzon & Conrad, 2023); (3) blended or technology-supported learning ("blended learning", "hybrid learning", "flipped classroom", "flipped learning", "e-learning", "technology-enhanced learning", "mobile learning"); and (4) game-based pedagogies ("TGfU", "Teaching Games for Understanding", "Game Sense", "tactical games", "sport education", "game-based learning", "game-centred approach", "models-based practice", "gamification") (Mo et al., 2024; Teraoka et al., 2021). To improve sensitivity for interdisciplinary overlap, neighboring-field terms were also included where relevant, and citation chasing was used as a supplementary search procedure.

Eligibility criteria

Eligibility criteria were defined to match the review aim of synthesizing pedagogical models, design principles, and PL-relevant outcomes in digitally scaffolded outdoor game-centred pedagogy in primary PE. Included studies were peer-reviewed journal articles published between 2020 and 2025 in relevant subject areas and conducted in primary school contexts involving children aged approximately 6–12 years and/or primary PE teachers. The population criterion therefore referred to primary school learners, primary PE teachers, or school-based primary PE contexts. Studies were eligible

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when they examined at least one PE-relevant strand with clear pedagogical intent: outdoor learning or outdoor PE, blended/hybrid/flipped or other technology-supported delivery, and/or game-centred pedagogy or models-based practice. Eligible studies also had to report extractable design evidence or outcomes linked to physical literacy (PL) domains or close proxies, including movement competence or fitness, motivation or enjoyment, confidence or self-efficacy, knowledge or understanding, participation or physical activity, and tactical decision making. Empirical studies and evaluative design evidence were included.

Studies were excluded if they were non-peer-reviewed, published outside 2020–2025, conducted only in secondary, higher education, clinical, community, or other non-school settings, or unrelated to PE-relevant pedagogical design. Studies were also excluded when they reported only technical drills, technology use without instructional design, outdoor activity without a PE learning focus, or insufficient PL-relevant evidence to support synthesis. Purely conceptual or opinion papers were excluded unless used only for definitional clarification. To address the emerging and uneven nature of the evidence base, included studies were classified during extraction as direct evidence, partial evidence, or supporting/adjacent evidence. Direct evidence referred to studies in primary PE that combined game-centred pedagogy with either outdoor learning or digital scaffolding and reported PL-related outcomes. Partial evidence referred to primary PE studies addressing only one or two of the focal components. Supporting or adjacent evidence referred to studies from related school-based or PE contexts that informed design principles, implementation conditions, or measurement issues but did not fully meet the integrated configuration. This classification was used to avoid overstating the maturity of the evidence base.

Screening and selection process (PRISMA)

A two-stage PRISMA-aligned screening process was used: title/abstract screening followed by full-text eligibility assessment (Alé-Silva et al., 2025; Sun & Sailer, 2025). Four reviewers screened studies independently using the predefined criteria. Disagreements were resolved by consensus, with adjudication by a fifth reviewer when necessary. Before full screening, the reviewers discussed the eligibility criteria and coding categories to ensure a shared interpretation of the review scope. No formal

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Cohen's kappa coefficient was calculated; therefore, screening reliability was strengthened procedurally through independent screening, predefined criteria, consensus meetings, and fifth-reviewer adjudication. The PRISMA flow identified 2,303 records through database searching: 1,710 from Scopus and 593 from Web of Science. After removal of duplicates and records excluded by automation tools or other reasons, 504 records were screened. Of these, 430 were excluded because they did not match the context or outcome criteria. Seventy-four reports were sought for retrieval, six were not retrieved, and 68 full-text reports were assessed for eligibility. A further 45 reports were excluded because they did not focus on relevant keywords or because they were conceptual or had poor methodological quality. Finally, 23 studies were included in the review. The screening and selection process is shown in Figure 1.

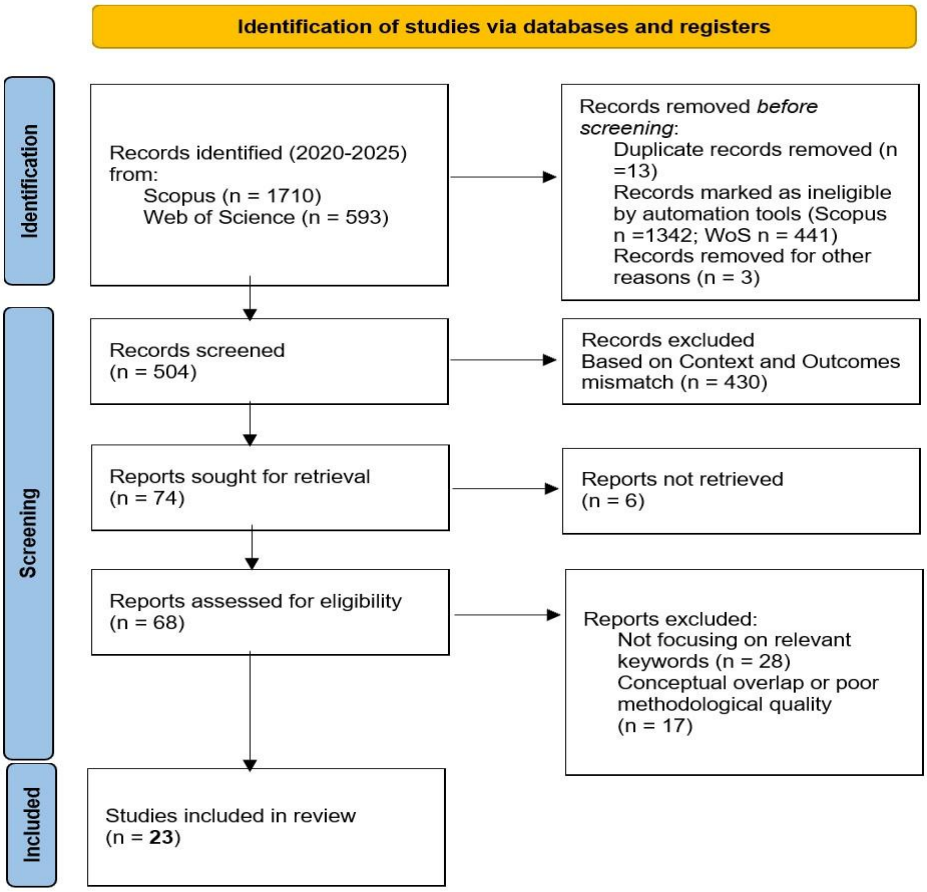

Figure 1. Presents the PRISMA flow diagram detailing this screening and selection process

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Data extraction

A structured extraction template was used to support consistent synthesis across diverse study designs. The extraction template functioned as the main review instrument. Extracted data included bibliographic information, country, sample characteristics, and instructional context, including whether outdoor delivery or digital support was reported. The template also captured pedagogical model(s), instructional design features, outcome domains and measures, implementation factors, key findings, and stated limitations. Implementation-related variables included teacher training, facilities and space requirements, technology access, equity constraints, safety or risk-management considerations, and fidelity notes where available. Additional fields were added to identify whether each study provided direct, partial, or supporting/adjacent evidence for the integrated concept of digitally scaffolded outdoor game-centred primary PE. This allowed the synthesis to distinguish evidence that directly examined the review focus from evidence that informed only one component or an adjacent design issue.

Quality appraisal

Because the included evidence spanned experimental, quasi-experimental, qualitative, and mixed-method designs, quality appraisal followed a pluralist logic. The review drew on appraisal principles commonly used in PE pedagogy syntheses, including MMAT-style evaluation for diverse study types and Cochrane-aligned risk-of-bias logic for intervention studies (Ranken et al., 2024). Appraisal focused on four criteria: clarity of intervention description, credibility of outcome measures, completeness of reporting, and evidence of implementation fidelity where reported (Teraoka et al., 2021).

Each criterion was coded as adequate, partial, or unclear/weak. Studies were then interpreted as higher, moderate, or lower methodological confidence according to the overall pattern of appraisal judgments. Higher-confidence studies provided clear intervention or design descriptions, credible outcome measures, sufficient reporting, and at least some evidence of implementation fidelity. Moderate-confidence studies met some but not all criteria. Lower-confidence studies had limited design detail, weak or unclear outcome measurement, incomplete reporting, or little information about fidelity. The appraisal was not used as a purely mechanical exclusion tool after eligibility screening; instead, it informed the weight given to each study during synthesis. Stronger claims were

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based primarily on higher-confidence and directly relevant studies, while lower-confidence or adjacent studies were used more cautiously to support interpretation, identify design considerations, or frame future research needs.

Synthesis strategy

Given the heterogeneity of designs, outcomes, and reporting practices, findings were synthesized thematically (Dyson et al., 2020; Neville et al., 2022). Studies were first grouped by their primary conceptual contribution and then synthesized across four analytic dimensions aligned with the review questions: (1) pedagogical models and hybridization patterns; (2) design principles and features, including digital scaffolds and assessment coherence; (3) effectiveness evidence related to PL and associated outcomes; and (4) contextual moderators such as teacher capacity, facilities, equity, technology constraints, and safety culture. Within each dimension, evidence was interpreted according to three considerations: relevance to primary PE, degree of integration among game-centred pedagogy, outdoor learning, and digital scaffolding, and methodological confidence from the quality appraisal. This strategy allowed comparison across diverse evidence while preserving traceability between design features, reported outcomes, and implementation conditions, which is important in a field marked by uneven reporting and variable evidence quality (Short et al., 2021). Because of heterogeneity in interventions, populations, outcome measures, and reporting quality, meta-analysis was not conducted. Instead, the synthesis prioritised transparent thematic comparison and cautious interpretation of direct, partial, and adjacent evidence.

Results

The 23 included articles represented heterogeneous evidence in terms of study design, sample, setting, and relevance to the integrated focus of this review. The evidence base included intervention studies, teacher surveys, qualitative multicase research, observational and validation studies, and supporting school-based or PE-related evidence. Some studies were conducted directly in primary PE settings, whereas others involved mixed primary–secondary samples, after-school programmes, teacher-only samples, or adjacent educational contexts. Therefore, the synthesis distinguishes between direct evidence, partial evidence, and supporting/adjacent evidence. Direct evidence refers to

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studies most closely aligned with primary PE and PL-related outcomes; partial evidence refers to studies addressing only one or two components of the review focus; and supporting/adjacent evidence informs mechanisms, design principles, or implementation conditions but does not directly test the full outdoor–digital–game-centred configuration.

Quality appraisal also informed interpretation. Higher-confidence claims were drawn from studies with stronger design features, clearer outcome measures, or validated instruments. Moderate-confidence evidence included comparison, survey, or qualitative studies that informed implementation and pedagogical mechanisms but offered limited causal inference. Lower-confidence or partial evidence was used cautiously, especially when studies had small samples, single-group pre–post designs, mixed school levels, after-school settings, or limited reporting of outdoor and digital design features. Because effect sizes and statistical parameters were not reported consistently across the evidence base, findings are synthesized directionally and interpreted according to study design, relevance, and methodological confidence rather than pooled statistically.

Theme 1 — Pedagogical model configurations for digitally scaffolded outdoor game-centred PE

Table 1 indicates three main configurations relevant to digitally scaffolded outdoor game-centred pedagogy in primary PE: hybrid game-centred models, teacher enactment of game-based approaches, and assessment-centred work that operationalizes physical literacy (PL) in authentic game contexts. Across these configurations, model choice matters not only for tactical learning but also for engagement, assessment feasibility, and alignment with the multidimensional domains of PL (Barratt et al., 2024; Blain et al., 2022; Carl et al., 2023). However, the studies in this theme do not provide equal levels of evidence for the full integrated concept. Some studies offer direct or near-direct evidence for primary PE and PL-related learning, whereas others provide partial evidence because they focus on hybrid models, teacher perceptions, game-based assessment, after-school activity, or mixed-level samples without explicitly including both outdoor and digital scaffolding.

The strongest comparative evidence within this theme comes from hybrid game-centred models. In the “Rosquilla” studies, both a game-centred model and a hybrid game-centred + Sport Education model improved tactical knowledge, while the hybrid

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condition also produced the most favorable enjoyment profile (Calle et al., 2024, 2025). These findings suggest that hybridization can strengthen coherence between tactical learning and social organization, thereby supporting both cognitive and affective dimensions of PL. Nevertheless, this evidence should be interpreted as moderate and partial rather than conclusive for the full review focus, because the studies included mixed primary and early secondary samples and did not explicitly report outdoor learning or digital scaffolding as design features. Thus, these studies support the game-centred and hybrid-pedagogy component of the review, but they do not directly test digitally scaffolded outdoor game-centred PE.

A second configuration concerns teacher uptake of game-based approaches. Survey evidence shows that teachers are more likely to report enacting GBAs when they plan around tactical problems and progressive complexity (Maleki et al., 2023). Yet large-sample primary teacher evidence also indicates weak alignment between active methodologies and formative assessment or grading, pointing to a coherence problem that may limit PL-oriented implementation (Arija Mediavilla et al., 2025). In this sense, teacher capacity is not only a matter of model selection but of aligning aims, tasks, feedback, and evidence practices. These studies do not directly measure pupil PL outcomes, but they provide important implementation evidence because they show that teachers' planning competence and assessment coherence determine whether game-centred models can be enacted with fidelity in primary PE. Therefore, this evidence was treated as implementation-relevant rather than as direct effectiveness evidence.

A third configuration is assessment-centred work. Wilkie et al. (Wilkie et al., 2022, 2023) provide the clearest methodological foundation for observing PL in authentic game play through ecological-dynamics-informed tools, including a validated observational instrument with 9 ecological conceptualisations, 15 variables, and 44 items. This evidence was considered methodologically important because it strengthens authentic assessment of game-based PL behaviours, but it was not interpreted as intervention-effect evidence. Other intervention studies mainly contribute evidence for physical competence, such as manipulative skill improvement in Grade 4 learners (Satria et al., 2024) and fitness gains in a 12-week afterschool RCT (Onarici Gungor et al., 2025). The Satria et al. (2024) study is relevant to primary PE but provides lower-confidence

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causal evidence because it used a small one-group pre–post design. In contrast, the Onarici Gungor et al. study provides stronger causal evidence because it was an RCT, but its after-school setting limits direct transfer to curriculum PE. Overall, Theme 1 shows that current evidence is strongest for game-centred and hybrid pedagogy, game-based assessment, and competence-related outcomes, but much weaker for explicitly designed outdoor and digitally scaffolded features.

Table 1. Summary of pedagogical model configurations relevant to digitally scaffolded outdoor game-centred pedagogy in primary PE

Study	Model / focus	Context & design	Hybrid / digital / outdoor	Main contribution to review	Key note
(Calle et al., 2024)	Game-Centred Model vs Hybrid Game-Centred + Sport Education	Pre–post comparison; n = 136; Grades 5–6 primary + Year 1 secondary	Hybrid explicit; outdoor not specified	Improved declarative and procedural tactical knowledge	Useful hybrid comparison; mixed school levels
(Calle et al., 2025)	Game-Centred Model vs Hybrid Game-Centred + Sport Education	Intervention; n = 136; mixed primary + secondary	Hybrid explicit; outdoor/digital not specified	Improved enjoyment; hybrid showed the most favorable profile	Strong affective evidence; mixed levels
(Carter-Thuillier et al., 2023)	TGfU + Cooperative Learning hybrid	Qualitative multicase; after-school sport in Spain and Chile	Hybrid; no digital; outdoor not specified	Supported inclusion, relationships, and participation	Rich context; limited causal and standardized PL evidence
(Maleki et al., 2023)	Teacher-reported Game-Based Approaches	Survey; n = 256 teachers; 40.6% primary	No digital; outdoor not specified	Planning around tactical problems and complexity predicted GBA enactment	Highlights teacher capacity; self-report only
(Arija Mediavilla et al., 2025)	Active methodologies, hybrid models, and assessment	Survey; n = 310 primary PE teachers	Hybrid included; outdoor not specified	Weak alignment between active methods and formative assessment/grading	Shows assessment coherence risk; no pupil outcomes
(Wilkie et al., 2022)	Ecological-dynamics games-based PL assessment	Pilot observational study in invasion-game PE	Digital video tagging; outdoor not specified	Differentiated lower vs higher PL behaviours in game play	Strong theory–method link; not an effect study
(Wilkie et al., 2023)	Validated observational instrument for	Multi-stage validation study	Tool development; outdoor not specified	Provided valid and reliable gameplay PL assessment framework	Important measurement advance; no

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Study	Model / focus	Context & design	Hybrid / digital / outdoor	Main contribution to review	Key note
	games-based PL				effectiveness data
(Satria et al., 2024)	Game-based PE model for manipulative skills	One-group pre–post; n = 25; Grade 4; 8 sessions	No digital; outdoor not specified	Improved manipulative movement skills	Relevant to competence; small sample and no control
(Onarici Gungor et al., 2025)	Afterschool game-based PA program (AGPAP)	RCT; n = 120; age 9–10; 12 weeks	No digital; outdoor not specified	Improved multiple fitness components versus control	Strongest causal evidence; after-school rather than curriculum PE

Theme 2 — Design principles and features that enable physical literacy development

Table 2 shows that PL-oriented design depends less on adding technology or outdoor activity as separate elements and more on creating learning conditions that support representative game play, meaningful participation, and credible assessment. Across the evidence base, the most consistent principles are affordance-led task design, assessment coherence, selective hybridization, progressive complexity, inclusive differentiation, and lightweight motivational scaffolds. Because the included studies varied in context, design quality, and degree of integration, these principles should be interpreted as synthesized design patterns rather than as universal prescriptions. They were most strongly supported when evidence came from primary PE or validated game-based assessment studies, and more cautiously interpreted when drawn from mixed-level, after-school, or adjacent educational contexts.

Representative tasks are central because PL develops through child–environment interaction rather than isolated technique rehearsal. From this perspective, outdoor spaces are valuable when they expand affordances and allow more flexible constraint manipulation, while digital supports are useful only when they remain light and do not displace movement time (Wilkie et al., 2022, 2023). This interpretation is supported most directly by game-based PL assessment evidence, which shows that children's decision making, movement adaptability, and tactical behaviours can be observed in authentic game contexts rather than only through isolated skill tests (Wilkie et al., 2022, 2023).

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However, because the reviewed assessment studies did not always include explicit outdoor delivery, the outdoor implication should be treated as a design inference grounded in affordance-rich learning environments, not as direct effectiveness evidence. This principle is closely linked to assessment: if learning is expected to emerge through authentic game play, then evidence must also be gathered in game contexts.

Assessment coherence is therefore a design requirement rather than a later add-on. The reviewed literature suggests that active pedagogies lose credibility when formative assessment and grading remain weakly aligned to learning intentions (Arija Mediavilla et al., 2025). This evidence was interpreted as implementation-relevant rather than direct pupil-outcome evidence, because it was based on teacher survey data and did not directly measure students' PL development. For the same reason, hybridization appears most effective when it is selective and pedagogically purposeful. Comparative and synthesis evidence associates hybrid models with stronger enjoyment, motivation, responsibility, and performance, particularly when tactical problem solving is combined with stable social structures such as roles or affiliation (Calle et al., 2025; Manso-Lorenzo et al., 2024; Pan et al., 2023). Nevertheless, the strength of this claim varies across studies. Evidence from hybrid models is useful for identifying motivational and social mechanisms, but several studies involved mixed school levels or non-primary samples; therefore, transfer to primary PE should be interpreted cautiously.

The evidence also highlights the importance of progression, differentiation, and dosage. Teachers are more likely to enact game-based learning successfully when they manage tactical complexity deliberately (Maleki et al., 2023), while primary-age interventions show that adaptation by initial ability can support competence gains (Satria et al., 2024) and sustained cycles can strengthen fitness-related outcomes (Onarici Gungor et al., 2025). The strength of this evidence is uneven: Satria et al. (2024) provides direct but lower-confidence primary PE evidence because of its small one-group pre–post design, whereas Onarici Gungor et al. (2025) provides stronger causal evidence through an RCT but in an after-school setting rather than regular curriculum PE.

Additional supports such as ARCS-based motivation scaffolding, simple gamification, and cooperative culturally inclusive structures may enhance engagement when they are tightly aligned to learning goals and governed to avoid unhealthy

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competition or exclusion (Carter-Thuillier et al., 2023; Jhang et al., 2025; Kozub et al., 2024; Luo & Li, 2024; Smirani & Yamani, 2024). Because some of these studies came from adjacent or non-primary contexts, they were used mainly to support design interpretation rather than to establish direct effectiveness for holistic PL. Overall, Theme 2 indicates that the most PL-aligned designs are structured, motivation-supportive, assessment-aware, and explicitly inclusive, but the evidence is strongest for competence, enjoyment, assessment feasibility, and implementation coherence, and weaker for fully integrated outdoor–digital–game-centred PL outcomes.

Table 2. Summary of design principles for digitally scaffolded outdoor game-centred pedagogy in primary PE to foster physical literacy

Design principle	Concise description / unit feature	PL domains targeted	Evidence base	Key note for design
Affordance-led representative task design	Modified outdoor games foreground child–environment interaction and adaptive decisions.	Physical; Cognitive; Affective; Social	(Wilkie et al., 2022)	Progress complexity gradually and ensure safe, equitable participation.
Games-based PL assessment embedded in play	Short observation windows are used during authentic game play.	Cognitive; Physical; Social	(Wilkie et al., 2022)	Keep indicators brief and feasible for regular classes.
Validated observational instruments for gameplay PL	Structured rubrics support more valid and reliable in-game assessment.	Cognitive; Physical; Social	(Wilkie et al., 2023)	Use a core subset for teaching and fuller coding for research or audits.
Assessment coherence	Learning goals, tasks, evidence, feedback, and grading are aligned.	Cognitive; Affective; Social	(Arija Mediavilla et al., 2025)	Avoid assessment overload and reliance on traditional grading only.
Selective pedagogical hybridization	Complementary models are combined to support tactical, social, and motivational outcomes.	Cognitive; Affective; Social	(Calle et al., 2025; Manso-Lorenzo et al., 2024; Pan et al., 2023)	Blend selectively; added complexity requires teacher expertise.
Enjoyment-focused and autonomy-supportive climate	Choice, cooperation, and supportive participation structures enhance enjoyment.	Affective; Social; Participation	(Calle et al., 2025)	Use mastery-oriented rather than comparison-heavy climates.
Tactical-problem planning and progressive complexity	Lessons progress through tactical problems and staged challenge.	Cognitive; Physical	(Maleki et al., 2023)	Use simple-to-complex progression and avoid reverting to isolated drills.

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Design principle	Concise description / unit feature	PL domains targeted	Evidence base	Key note for design
Inclusive differentiation by initial ability	Tasks are adapted to readiness to preserve challenge, confidence, and access.	Physical; Affective; Cognitive	(Satria et al., 2024)	Use flexible grouping to reduce stigma and workload.
Game modification for active time and fitness dose	Rules, teams, and equipment are adjusted to increase active involvement.	Physical; Affective	(Khairuddin et al., 2023; Onarici Gungor et al., 2025)	Balance intensity with tactical learning and recovery.
Sustained dosage and structured cycles	Programs are delivered across repeated cycles with clear progression.	Physical; Affective; Cognitive	(Onarici Gungor et al., 2025)	Use season-like structure to maintain continuity and engagement.
Motivation scaffolding (ARCS)	Attention, relevance, confidence, and satisfaction are built into tasks and feedback.	Affective; Physical; Cognitive	(Luo & Li, 2024)	Prioritize informational feedback over controlling rewards.
Gamification with governed competition	Points, badges, or challenges are used selectively to support engagement.	Affective; Social; Cognitive	(Kozub et al., 2024; Parra-González et al., 2020; Smirani & Yamani, 2024)	Align rewards with mastery and cooperation; provide low-tech options.
Cognitive-load management via game-based review	Simple review mechanics are used to maintain attention without overloading learners.	Cognitive; Affective	(Jhang et al., 2025)	Keep mechanics minimal and tightly linked to movement tasks.
Culturally responsive cooperative design	Cooperative structures and multicultural game content support inclusion and belonging.	Social; Affective; Participation	(Carter-Thuillier et al., 2023)	Require culturally responsive facilitation, not token inclusion.

Theme 3 — Effectiveness evidence on physical literacy and proximal outcomes

Table 3 indicates that the strongest effectiveness evidence currently clusters around three outcomes relevant to PL: physical competence/fitness, affective engagement, and cognitive–perceptual game behaviour. However, these outcomes should be interpreted as PL-related or proximal indicators rather than as comprehensive evidence of holistic PL development, because most studies measured selected domains rather than the full multidimensional construct of PL. Effects are most convincing in studies using randomization or comparison groups, whereas single-group pre–post work provides useful but weaker causal evidence (Barratt et al., 2024; Blain et al., 2022; Carl et al., 2023). Accordingly, the synthesis gives greater interpretive weight to randomized or

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comparative designs, while treating single-group, mixed-level, after-school, and adjacent-context studies as more limited sources of effectiveness evidence.

The clearest effectiveness signal concerns competence and fitness. The highest-rigor study is a 12-week RCT in n = 120 children aged 9–10, where an afterschool game-based physical activity program improved multiple fitness indicators relative to regular PE (Onarici Gungor et al., 2025). This study provides higher-confidence evidence for fitness-related outcomes because of its randomized design and sample size; however, its after-school setting means that transferability to regular curriculum PE should be interpreted cautiously. Smaller school-based studies reported similar directions of effect for manipulative skills and coordination (Masrun et al., 2025; Satria et al., 2024), but these studies offer more limited evidence for holistic PL because they focus mainly on physical outcomes. For example, Satria et al. (2024) is directly relevant to primary PE but provides lower-confidence causal evidence because it used a small one-group pre–post design. Masrun et al. (2025) supports early motor-development mechanisms, but the younger sample and narrower outcome focus limit its direct relevance to primary PE-based PL.

A second signal concerns affective outcomes. Calle et al. (2025) found that both a game-centred model and a hybrid game-centred + Sport Education model increased positive enjoyment and reduced negative enjoyment, with the hybrid condition showing the most favorable profile. This provides useful evidence for the affective domain of PL, but it remains partial because the study involved mixed primary and secondary learners and did not explicitly include outdoor or digital scaffolding. Luo and Li (Luo & Li, 2024) similarly reported that an ARCS-based intervention improved motivation, confidence, satisfaction, and skill performance. This finding supports the relevance of motivational scaffolding, but it should be interpreted as evidence for selected affective and skill outcomes rather than for multidomain PL as a whole. These studies support the plausibility of enjoyment and motivation as pathways to sustained participation, although behavioural participation outcomes remain undermeasured. Therefore, the evidence for affective outcomes is promising, but still insufficient to conclude that game-based, outdoor, and digitally scaffolded designs consistently produce sustained participation beyond the intervention period.

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A third contribution is improved measurement of cognitive–perceptual PL behaviours. Wilkie et al. (Wilkie et al., 2022, 2023) do not estimate intervention effects directly, but they strengthen the evidence base by enabling valid observation of decision making and functional game behaviour in authentic contexts. These studies should therefore be interpreted as higher-value measurement evidence rather than effectiveness evidence. Their main contribution is to show how PL-related behaviours can be assessed authentically during game play, which addresses a key limitation in studies that rely only on isolated skill, fitness, or enjoyment indicators. Transferable support for hybrid and modified-game logic is also visible in adjacent non-primary studies, where hybrid TGfU–Sport Education and game modification approaches improved motivation, enjoyment, responsibility, performance, or fitness (Khairuddin et al., 2023; Pan et al., 2023). However, these adjacent studies were not treated as direct evidence for primary PE because they involved non-primary or less directly aligned contexts. They were retained only to support interpretation of mechanisms and design logic. Overall, Theme 3 suggests that game-based and hybrid approaches may improve PL-related outcomes, but evidence remains uneven for integrated multidomain PL assessment and for explicit outdoor or digital design features. The strongest claims can be made for competence-related, affective, and assessment-related outcomes; claims about holistic PL development and fully integrated outdoor–digital–game-centred pedagogy remain tentative.

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Table 3. Summary of effectiveness and outcome evidence for game-based and hybrid game-based learning in physical education

Study	Intervention / context	Outcome focus	Main finding	Key note
(Satria et al., 2024)	Game-based PE model; Grade 4; n = 25; 8 sessions	Manipulative skills	Manipulative movement skills improved after the intervention	Relevant to primary PE, but no control group and measurement details were limited
(Luo & Li, 2024)	ARCS-based table tennis PE vs traditional teaching; 16 weeks	Motivation, confidence, satisfaction, skill	Confidence, satisfaction, and skill outcomes improved versus control	Comparison design supports interpretation, but participant details were incompletely reported
(Onarici Gungor et al., 2025)	Afterschool game-based PA program vs regular PE; RCT; n = 120; 12 weeks	Fitness / physical competence proxies	Intervention improved multiple fitness components relative to control	Strongest causal evidence; after-school context may limit direct transfer to curriculum PE
(Masrun et al., 2025)	Fun game-based movement learning vs control; age 5–6; n = 45	Foundational coordination	Experimental group showed greater coordination gains than control	Relevant for early PL foundations, but younger than most primary PE samples
(Calle et al., 2025)	Game-centred model vs hybrid Game-Centred + Sport Education; n = 136	Enjoyment	Positive enjoyment increased and negative enjoyment decreased; hybrid was most favorable	Strong affective evidence, but mixed primary–secondary sample and limited competence outcomes
(Wilkie et al., 2022)	Pilot games-based PL assessment during invasion games	Game behaviour / cognitive–perceptual PL	Observed differences between lower and higher PL behaviours during game play	Important for authentic PL assessment, but not an intervention-effect study
(Wilkie et al., 2023)	Validation of observational gameplay PL instrument	Measurement validity and reliability	Instrument showed supported validity and substantial-to-almost-perfect reliability	Key measurement contribution, but does not estimate learning effects directly
(Pan et al., 2023)	Hybrid TGfU–Sport Education vs TGfU; junior high; n = 90	Motivation, enjoyment, responsibility, performance	Hybrid model outperformed TGfU across reported outcomes	Useful for mechanism support, but not a primary sample
(Khairuddin et al., 2023)	Game modification vs movement-activity approach; junior high; n = 100	Fitness	Both approaches improved fitness, with stronger gains in the game-modification condition	Supports transferable design logic, but not primary PE evidence

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Theme 4 — Implementation, equity, and context: what moderates success

Table 4 shows that the success of digitally scaffolded outdoor game-centred pedagogy depends not only on pedagogical intent but also on implementation capacity and context. Across the reviewed studies, the most important moderators are teacher competence, assessment feasibility, infrastructure and facilities, digital usability, equity conditions, and safety culture. These factors determine whether the mechanisms assumed to support PL—competence-building practice, motivation, social connection, and meaningful participation—can be enacted consistently across settings (Barratt et al., 2024; Carl et al., 2023). However, the evidence in this theme should be interpreted primarily as implementation and contextual evidence rather than as direct intervention-effect evidence. Several studies informed the synthesis through teacher surveys, qualitative cases, facility analyses, equity-focused modelling, or adjacent technology studies. Therefore, Theme 4 explains the conditions under which the reviewed pedagogical configuration be feasible, transferable, and fair, rather than proving its effectiveness as a fully integrated intervention.

Teacher capacity is central. Qualitative evidence shows that prior training and culturally inclusive practice can support social inclusion and interpersonal learning (Carter-Thuillier et al., 2023), while survey evidence indicates that active pedagogies often remain weakly aligned with formative assessment and grading in primary PE (Arija Mediavilla et al., 2025). Planning competence also matters: teachers are more likely to perceive that they enact GBAs when they can organize lessons around tactical problems and complexity progression (Maleki et al., 2023). These studies provide moderate implementation evidence because they clarify teacher-level conditions, but they do not directly estimate effects on pupils' multidomain PL outcomes. This suggests that successful implementation depends on micro-pedagogical skill, not simply on using games. In practical terms, teacher capacity includes the ability to sequence tactical problems, adapt tasks for diverse learners, provide formative feedback, use assessment evidence, and manage outdoor or digitally supported activities without reducing movement time.

Structural conditions are equally influential. Facilities vary by geography and school type (Xia et al., 2022), cross-context digital packages often require local adaptation

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(Lieberoth et al., 2025), and technology adoption depends on usability, usefulness, and flow (Ren et al., 2022). This evidence indicates that school context moderate implementation because outdoor space, equipment, connectivity, and staff support are not equally distributed across settings. Additional studies caution that poor tool quality, excessive screen dependence, unhealthy competition, and unnecessary cognitive load can weaken implementation unless digital features remain simple, purposeful, and aligned with movement-rich learning (Jhang et al., 2025; Kozub et al., 2024; Smirani & Yamani, 2024). Because several of these studies come from adjacent digital-learning contexts, they were used cautiously to identify design risks rather than to claim direct effectiveness in primary PE. The consistent implication is that digital scaffolds should be low-burden, usable, and pedagogically aligned, especially in schools with limited infrastructure.

Equity and safety are decisive moderators. Rural teachers report lower use of outdoor learning and ICT (Torkos & Egerău, 2020), socioeconomic conditions can shape who benefits most from outdoor activity promotion (Almagor et al., 2021), and low-income children may rely heavily on school-based opportunities such as outdoor recess and PE to achieve MVPA (Tyler et al., 2020). These findings show that digitally supported and outdoor PE designs unintentionally widen inequalities if they assume equal access to devices, connectivity, facilities, teacher expertise, or safe play spaces. Safety culture also matters because restrictive supervision can limit play affordances and reduce active engagement (Jerebine et al., 2022), while institutional barriers such as limited support, low teacher confidence, accountability pressures, and weather conditions can further constrain outdoor delivery (Neville et al., 2022; Richards et al., 2023; Robinson et al., 2021). The evidence therefore supports a balanced interpretation: safety management is necessary, but overly restrictive risk-avoidance reduce movement opportunities, autonomy, and meaningful participation. Overall, Theme 4 indicates that implementation, equity, and safety are not peripheral concerns but core determinants of whether this pedagogical approach can be effective and fair. Nevertheless, because much of this evidence is contextual rather than experimental, it should be understood as identifying implementation conditions and equity risks rather than demonstrating direct causal effects on PL.

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Table 4. Summary of implementation, equity, and contextual moderators relevant to digitally scaffolded outdoor game-centred pedagogy in primary PE

Moderator domain	Key factor	Main implication for implementation	Equity / design note	Evidence base
Teacher capacity	Cultural competence and prior training	Supports inclusive delivery and smoother implementation.	Important for culturally diverse learners; requires PD and reflective practice.	(Carter-Thuillier et al., 2023)
Teacher capacity	Culturally inclusive game content	Can strengthen belonging, participation, and social learning.	Reduces one-culture dominance; benefits from co-design with students/families.	(Carter-Thuillier et al., 2023)
Pedagogical coherence	Alignment of active methods with assessment/grading	Weak alignment can undermine feedback credibility and pedagogy.	Misalignment may disadvantage lower-skill learners.	(Arija Mediavilla et al., 2025)
Teacher planning	Planning around tactical problems and complexity	Supports stronger enactment of game-based approaches.	Requires coaching, planning tools, and teacher expertise.	(Maleki et al., 2023)
Assessment feasibility	Feasible game-performance assessment routines	Observation-based assessment can be difficult without training and streamlined indicators.	Schools with fewer supports face greater burden.	(Manso-Lorenzo et al., 2024)
Infrastructure and facilities	Reliability, adaptability, and available space	Condition whether outdoor–hybrid models are feasible and sustainable.	Low-resource schools need flexible, low-tech alternatives.	(Kozub et al., 2024; Xia et al., 2022)
Transferability	Local adaptation of digital game-based packages	Programs may not transfer well across contexts without adaptation and support.	Under-supported settings may show weaker outcomes.	(Lieberoth et al., 2025)
Digital usability	Tool quality, interaction limits, ease of use, and flow	Poor usability can reduce adoption, engagement, and continuity.	Digital divide risks remain important.	(Ren et al., 2022)
Gamification governance	Competition versus mastery orientation	Gamification may support engagement, but poorly governed competition can reduce learning quality.	Public comparison-sensitive learners disengage	(Kozub et al., 2024; Smirani & Yamani, 2024)
Cognitive efficiency	Cognitive-load management in hybrid tasks	Simple, focused review structures can improve motivation and retention.	Especially important for learners with lower prior knowledge.	(Jhang et al., 2025)

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Moderator domain	Key factor	Main implication for implementation	Equity / design note	Evidence base
Dose and relevance	Active time and student interest/value alignment	Higher movement dose and meaningful content support more positive lesson experiences.	Choice and participation structures should remain inclusive.	(Frömel et al., 2021; Simonton et al., 2024)
Equity	Rural–urban digital access differences	Lower ICT and outdoor-learning use may constrain implementation in rural settings.	Requires offline-first and targeted support strategies.	(Torkos & Egerău, 2020)
Equity	SES-related unequal benefit from outdoor PA promotion	Without mitigation, benefits may be greater in higher-SES groups.	Targeted support is needed to avoid widening inequalities.	(Almagor et al., 2021)
Equity	Dependence on school-based PA in low-income settings	Outdoor recess and PE remain critical for activity opportunities.	Digital additions should not replace movement-rich school time.	(Tyler et al., 2020)
Safety culture	Restrictive supervision and risk-averse rules	Overly restrictive approaches can reduce affordances, engagement, and competence-building.	Balanced risk management is preferable to risk elimination.	(Jerebine et al., 2022)
Institutional context	Administrative support, PD, time, and resources	Supportive leadership and resourcing strengthen feasibility and sustainability.	Under-supported schools face higher implementation burden.	(Neville et al., 2022; Robinson et al., 2021)
Context dependency	Weather and environmental conditions	Feasibility and continuity vary by season and local conditions.	Flexible planning and indoor alternatives remain important.	(Richards et al., 2023)

Discussion

Interpreting what works: motivation, design coherence, and physical literacy

This review suggests that digitally scaffolded outdoor game-centred pedagogy may support physical literacy (PL) when it operates as a coherent, motivation-supportive learning system rather than as a simple combination of technology, outdoor activity, and games. This claim should be interpreted cautiously because the evidence is stronger for game-centred and hybrid pedagogies than for fully integrated outdoor–digital–game-centred designs. Across the reviewed studies, PL is best understood as an interdependent construct involving competence, motivation/confidence, knowledge/understanding, and participation; therefore, gains in one domain are unlikely to be meaningful without support from the others (Barratt et al., 2024; Blain et al., 2022; Carl et al., 2023).

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Accordingly, the discussion distinguishes direct evidence from primary PE or closely aligned studies, supporting evidence from adjacent or partial contexts, and interpretive inferences derived from combining these strands.

The clearest design pattern links autonomy support, inclusive differentiation, and formative assessment with stronger engagement and motivation. Direct evidence for this pattern is clearest in game-centred and hybrid pedagogical studies, whereas evidence for outdoor and digital components is more often partial or supporting. This interpretation is consistent with broader evidence showing that need-supportive game-based pedagogies can strengthen intrinsic motivation and sustained participation, particularly when framed through self-determination theory (Flores-Cidoncha, 2025; Hernández et al., 2020; Rojo, 2025). In this review, however, these outcomes appear to depend less on "technology" or "outdoor" delivery alone than on concrete pedagogical features such as representative tasks, progressive complexity, and feasible feedback. Thus, technology and outdoor settings should not be interpreted as independent solutions; their value depends on how they are embedded within coherent pedagogical design.

The enjoyment findings reported by Calle et al. (2025) provide the strongest affective support for this interpretation. In n = 136 learners, both a game-centred model and a hybrid game-centred + sport education model improved positive enjoyment and reduced negative enjoyment, with the hybrid condition showing the most favorable profile. However, this evidence should be treated as partial rather than definitive for the review's full focus because the study involved mixed primary and secondary learners and did not explicitly test outdoor learning or digital scaffolding. Because PL includes valuing and sustaining participation in physical activity, enjoyment and autonomous motivation should be treated as meaningful pathways rather than secondary outcomes, which aligns with the SDT–PL linkage proposed by Blain et al. (2022). Therefore, the strongest conclusion is that game-centred and hybrid pedagogies can support affective conditions related to PL, while stronger evidence is still needed to confirm whether these gains transfer to fully integrated digitally scaffolded outdoor PE designs.

These findings also clarify the role of design coherence. In game-centred practice, the game itself functions as the learning environment, so task representativeness and progressive complexity provide the structure that makes autonomy support educationally

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productive rather than chaotic. Teacher evidence suggests that successful enactment depends on deliberate planning around tactical problems and tactical complexity (Maleki et al., 2023), while broader work indicates that staged game-like challenges can support both learning and motivation when they are monitored and differentiated appropriately (Rojo, 2025). In primary PE, this is especially important because autonomy without progression can easily become unstructured activity. The hybrid findings of Calle et al. (2024, 2025) further suggest that added structure, such as roles, affiliation, and continuity, may strengthen relatedness and meaning. The implication for outdoor and digital design is therefore inferential rather than directly proven by the included evidence: outdoor settings enrich representativeness through space and variability, while digital scaffolds support progression, cueing, feedback, and reflection if they remain lightweight and do not reduce active learning time.

Competence pathways and the measurement challenge

Although motivation is central to PL, the review also indicates that competence-related outcomes may improve when interventions are sufficiently structured and sustained. The clearest evidence is the 12-week randomized controlled trial with n = 120 children aged 9–10, in which an afterschool game-based physical activity program improved handgrip strength, curl-ups, flexibility, power, and speed, while the control group showed no significant change (Onarici Gungor et al., 2025). This provides comparatively strong causal evidence for fitness-related outcomes, but it remains partial evidence for this review because the intervention was delivered after school and did not explicitly include outdoor or digital design features. Although these outcomes were framed as fitness rather than PL, they are widely used as proxies for the physical competence component of PL in school contexts. A smaller Grade 4 pre–post study (n = 25) similarly reported gains in manipulative movement skills across eight sessions and recommended adapting games to learners' initial ability levels (Satria et al., 2024). This study is more directly relevant to primary PE but provides weaker causal evidence because it used a small single-group pre–post design. Together, these studies suggest that competence gains in game-centred formats are plausible, but they depend on adequate dose, appropriate task design, and high participation density. They do not, however,

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establish comprehensive PL development across affective, cognitive, social, and behavioural domains.

A major limitation, however, is measurement. Many primary PE studies still assess only selected PL domains and rely on partial proxies rather than integrated PL evidence (Barratt et al., 2024; Carl et al., 2023). The most important advance in the reviewed literature comes from Wilkie et al. (2022), who conceptualise PL as an individual–environment interaction in invasion games, and from Wilkie et al. (2023), who validate an observational instrument with 9 ecological conceptualisations, 15 variables, and 44 items, showing strong content validity (Aiken's $V \geq 0.78$) and substantial-to-almost-perfect reliability by Cohen's κ. These contributions are important because they move assessment beyond isolated skill tests toward authentic game-context behaviour. They should be interpreted as strong measurement evidence rather than intervention-effect evidence. At the same time, feasibility remains a constraint: GPAI-related synthesis shows that video use is common, but coder training and live peer assessment are inconsistently reported across 27 papers (Manso-Lorenzo et al., 2024). For practice, this supports a tiered approach in which teachers use a small core set of observable indicators routinely, while fuller protocols are reserved for periodic evaluation or research. This recommendation is an interpretive implication from the measurement literature, not a directly tested implementation model.

Implementation, equity, and safety as determining conditions

The review also suggests that the same pedagogical design may not work equally well across schools because implementation capacity can moderate feasibility and transferability. Teacher competence and assessment coherence are especially influential. Arija Mediavilla et al. (2025), in a survey of n = 310 primary PE teachers, found weak alignment between active methodologies and formative assessment or grading practices. In PL-oriented PE, such incoherence may reduce the credibility of feedback and weaken motivation, particularly for children with lower initial skill. Likewise, Maleki et al. (2023) found that planning around tactical problems and tactical complexity predicted stronger perceptions of enacting game-based approaches in n = 256 PE teachers, indicating that teachers need support not only in "using games" but in sequencing tasks, managing progression, and integrating questioning and feedback. These findings are best interpreted

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as implementation evidence rather than direct evidence of pupil PL outcomes, because both studies focus on teacher practice or perception.

Contextual constraints also shape feasibility. Facility variability across 845 primary school samples shows that geography and school type affect the availability and quality of spaces and resources (Xia et al., 2022). Lieberoth et al. (2025) similarly note that digital game-based packages often require local adaptation rather than direct transfer. These findings support a principle of adaptation with integrity: core pedagogical principles should be preserved, but games, roles, and tools must remain flexible enough to fit local conditions. This is a supporting inference from contextual and adjacent evidence rather than a direct test of digitally scaffolded outdoor game-centred PE. It nevertheless helps explain why implementation conditions must be considered when translating review findings into practice.

Equity and safety are therefore central contextual considerations in outdoor–hybrid design. Rural teachers report the lowest ICT use in outdoor learning, and some may never use ICT in that context (Torkos & Egerău, 2020). Socioeconomic modelling further suggests that active travel and outdoor play initiatives can benefit higher socioeconomic groups more unless mitigation is planned (Almagor et al., 2021). In low-income school settings, multiple daily activity opportunities are needed to increase MVPA, with outdoor recess and PE making substantial contributions (Tyler et al., 2020). These findings do not directly test the review's integrated pedagogy, but they indicate equity risks that any digitally supported outdoor PE model must address. Digital elements should therefore complement, not displace, movement-rich opportunities for learners who depend most on school-based activity. Safety should be framed in the same way. Restrictive supervision can reduce play affordances and create risk-averse cycles that limit participation and competence development (Jerebine et al., 2022). Thus, safe design should emphasize balanced risk management, cooperative participation, low-tech alternatives, role rotation, and assessment practices that value effort, tactical understanding, and teamwork as well as performance (Caracuel-Cáliz et al., 2025; Gil-Arias et al., 2021; Ruggiero, 2025). These are practice implications drawn from equity, safety, and inclusion evidence, not direct causal findings from integrated digital–outdoor–game-centred interventions.

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Implications for research and practice

Overall, the evidence remains promising but not yet mature enough to support strong claims about fully integrated digitally scaffolded outdoor game-centred PL development. The clearest evidence currently supports game-centred and hybrid pedagogy, selected competence-related outcomes, enjoyment, and authentic game-based assessment. Evidence is weaker for explicit outdoor design, purposeful digital scaffolding, and multidomain PL development within a single integrated primary PE intervention. Three priorities follow. First, future studies should distinguish more clearly between intended design and actual delivery by documenting fidelity, teacher questioning, participation density, and assessment routines (Manso-Lorenzo et al., 2024). Second, outcome measurement should move beyond isolated proxies toward integrated game-context PL evidence, building on the observational pathway (Wilkie et al., 2023). Third, equity and context should be treated as core analytic concerns rather than background variables, given the implications of facility variability, rural ICT patterns, and socioeconomic gradients (Almagor et al., 2021; Torkos & Egerău, 2020; Xia et al., 2022).

The practical message is that this pedagogical configuration is most defensible when it is designed as a coherent system. Representative tasks and progressive complexity structure learning; autonomy support, inclusive differentiation, and formative assessment sustain motivation and equitable participation; and feasible assessment allows learning to be verified across domains. The strongest available evidence—including improved fitness in a 12-week RCT (Onarici Gungor et al., 2025) and improved enjoyment in a large-sample comparison study (Calle et al., 2025)—is consistent with this interpretation. However, these studies provide partial support rather than direct proof of the full integrated model: the RCT was after-school and fitness-focused, whereas the enjoyment study involved mixed school levels and did not explicitly include outdoor or digital scaffolding. Future progress will depend less on adding more technology or simply moving lessons outdoors than on principled design: lightweight digital support, affordance-rich outdoor learning, and teacher expertise in progression, questioning, differentiation, and feedback. Accordingly, the review's contribution is not to claim that a fully established model already exists, but to clarify the design principles, evidence

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boundaries, and implementation conditions that should guide future primary PE research and practice.

Conclusion

This systematic review synthesized peer-reviewed journal evidence published between 2020 and 2025 to clarify how digitally scaffolded outdoor game-centred pedagogy may support physical literacy (PL) in primary physical education (PE). Across 23 included studies, the most promising approaches combined representative game tasks and progressive complexity with autonomy-supportive, inclusive, and feedback-rich teaching. Competence-related gains were most evident when programs provided sufficient dose and participation density, while engagement and affective outcomes were consistently linked to autonomy support, inclusive differentiation, and formative assessment. However, these findings should be interpreted cautiously because the strongest evidence was concentrated in game-centred and hybrid pedagogies, competence-related outcomes, enjoyment, and game-based assessment, whereas direct evidence for fully integrated outdoor–digital–game-centred primary PE remained limited.

The review also shows that progress toward holistic PL remains limited by uneven measurement and implementation reporting. Many studies relied on partial proxies, such as enjoyment, fitness, or discrete skill tests, rather than integrated assessment across PL domains. At the same time, recent advances in games-based observational tools suggest a more credible pathway for assessing decision making and functional game behaviour in authentic contexts. Therefore, future evaluations should combine domain-specific indicators with multidimensional PL assessment to avoid treating isolated improvements in fitness, skills, or enjoyment as sufficient evidence of holistic PL development.

Implementation conditions strongly shaped transferability. Teacher capacity, pedagogical coherence, assessment feasibility, facilities and resources, equity and digital access, and safety culture in outdoor settings all influenced whether positive effects could be achieved and sustained. However, explicitly designed three-way integration remained rare: outdoor features were often treated as context rather than design variables, and digital elements were seldom described as purposeful scaffolds. This means that implementation should be equity-sensitive, adaptable to low-resource and low-technology conditions, and designed to protect rather than reduce active movement time.

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Future research should therefore prioritize designs that explicitly operationalize outdoor affordances and lightweight digital supports without reducing movement time, use validated game-context PL measures alongside core domain proxies, and test effectiveness through stronger comparative or longitudinal designs. Greater attention is also needed to equity-sensitive implementation in low-resource schools, including low-tech alternatives and balanced risk-management routines. Overall, the field appears promising, but more coherent and context-sensitive evidence is needed to move from fragmented innovation toward scalable practice that supports PL for all children. The main contribution of this review is to clarify the current evidence boundary: digitally scaffolded outdoor game-centred PE is a promising integrative direction, but it should currently be understood as an emerging pedagogical configuration rather than a fully established evidence-based model. Its future value will depend on rigorous, inclusive, and movement-rich designs that connect outdoor affordances, purposeful digital scaffolds, teacher capacity, and authentic PL assessment in primary PE.

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