

Physical Literacy as a Foundational Dimension of the Index for Embodied Education: Conceptual Architecture, Assessment Gaps, and Validation Pathway

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Abstract: This conceptual-methodological paper proposes physical literacy as a foundational component of the Index for Embodied Education. Building on physical literacy theory, embodied cognition, ecological dynamics, enactive pedagogy, and school-based research on self-regulated and cooperative learning, the paper develops an operational architecture for assessing how children move, perceive, regulate, understand, narrate, and share embodied experiences. The argument is organised around three aims: to reinterpret physical literacy through an embodied, ecological, and enactive lens; to identify unresolved assessment gaps in existing tools; and to propose a six-domain model for primary-school contexts. The proposed architecture includes motor competence, body awareness, motivation and confidence, knowledge and understanding, reflexive agency, and relational participation. Existing instruments such as CAPL-2, PPLI, PLAYself, and MAIA-2 are considered as partial anchors rather than ready-made solutions, while the domains of reflexive agency and relational participation require new operationalisation. A staged validation pathway is outlined, including expert Delphi review, cognitive interviews, pilot testing, confirmatory factor analysis, reliability assessment, measurement invariance, convergent and discriminant validity, and school feasibility criteria. The paper concludes that physical literacy, rethought through embodied and ecological perspectives, can provide the Index for Embodied Education with a theoretically grounded and pedagogically usable assessment framework.

Keywords: physical literacy; embodied education; assessment; validation; primary education.



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1. Introduction

The *Stati Generali dell'Embodied Education* (General Assembly on Embodied Education; hereafter, Stati Generali) have set in motion an ambitious collective endeavour: the construction of an Index for Embodied Education intended to function as an operational reference framework for research, teacher education, and curricular innovation. An index of this kind, if it is to be more than a rhetorical commitment, needs identifiable, measurable dimensions. One such dimension concerns the way learners engage with movement: not merely how well they perform motor tasks, but how they perceive their own bodies, make sense of physical experiences, exercise choice, and participate with others through embodied

interaction. At the same time, such dimensions should not be understood as reductive metrics, but as interpretive and formative coordinates for designing, observing, and improving embodied learning environments.

Physical literacy provides the most developed conceptual vocabulary for this dimension. Following the influential work of Edwards et al. (2017), the construct is widely understood as multidimensional, integrating motor competence, motivation and confidence, knowledge and understanding, and engagement in physical activity. Subsequent reviews have theorised its relevance to health outcomes through evidence-informed conceptual modelling (Cairney et al., 2019), its potential as an ecological and developmental framework (Rudd et al., 2020), and its growing international prominence (Bailey et al., 2023; Grauduszus et al., 2023). In the Italian context, physical literacy has been proposed as an epistemological framework capable of holding together the empirical-experimental and phenomenological traditions that characterise contemporary physical education (Cereda, 2025), and as a bridge between interdisciplinary research traditions within educational contexts (Cereda, 2026).

The difficulty, however, lies less in defining physical literacy than in assessing it. This gap has been noted repeatedly. As summarised by Piotrowski et al. (2025), a systematic review of 24 observational tools for fundamental movement skills found insufficient evidence to justify any of them for universal school screening in their current form (Eddy et al., 2020). Grauduszus et al. (2023) likewise emphasised that the holistic nature of physical literacy creates substantial measurement challenges. Edwards et al. (2018) documented a fragmented landscape in which strands of physical literacy are measured separately, rarely in an integrated manner, and almost never with attention to the embodied, situated, and relational qualities that distinguish a genuinely embodied understanding from a conventional multitrait assessment.

The purpose of this conceptual-methodological paper is to propose a coherent architecture for the physical literacy component of the Index for Embodied Education. Specifically, it aims to: (1) reinterpret physical literacy through an embodied, ecological, and enactive lens; (2) identify assessment gaps that are especially relevant to the construction of the Index; and (3) propose a six-domain architecture and staged validation pathway for primary-school contexts. The intent is to offer a disciplinary contribution to a collective process: what physical literacy, rethought through embodied cognition, can bring to the Index that the Stati Generali are building.

2. Methodological approach

Given its aim, the paper adopts a conceptual-methodological design rather than a systematic review or empirical validation study. The argument is developed through a critical narrative synthesis of three bodies of literature: physical literacy theory and assessment; embodied, ecological, and enactive approaches to learning; and school-based research on self-regulated and cooperative learning in physical education. The purpose of this synthesis is not exhaustive coverage, but the construction of a theoretically justified and operationally usable architecture for the physical literacy component of the Index.

Sources for the conceptual synthesis were selected purposively according to four complementary considerations: foundational influence within each tradition; direct relevance to physical literacy or embodied learning; explicit applicability to educational and assessment contexts; and capacity to clarify convergences, tensions,

or operational implications across traditions. Recent reviews were prioritised to map current debates, while seminal primary sources were retained where they defined the constructs under discussion. Because this was a critical narrative synthesis, no exhaustive database search, formal risk-of-bias assessment, or study-selection flow was undertaken.

The selection of assessment references was guided by four criteria: relevance to children or educational settings; capacity to represent one or more established domains of physical literacy; availability of published psychometric or validation evidence; and adaptability to formative use in school contexts. CAPL-2, PPLI, PLAYself, and MAIA-2 were therefore considered as anchor instruments, not as ready-made solutions. Their use in the proposed model is selective and developmental: existing tools provide validated starting points, whereas the domains of reflexive agency and relational participation require new operationalisation, pilot testing, and cultural validation.

3. Physical literacy through an embodied lens

3.1 From physical competence to embodied agency

Traditional approaches to physical literacy operationalise the construct through attributes possessed by the individual: motor competence scores, motivation levels, knowledge questionnaire results. The body appears as an object of measurement. An embodied perspective reverses this: the body is not what is measured but the medium through which meaning, affect, and social connection are constituted (Cereda, 2026). Physical literacy becomes not a score profile but a way of inhabiting the world, a formulation that returns, in fact, to the original phenomenological intent of the construct as articulated by Whitehead (2001), for whom physical literacy denotes an embodied disposition rather than a measurable competence inventory.

This reorientation draws on grounded cognition as systematised by Wilson (2002) and Barsalou (2010), who hold that cognitive processes are grounded in sensorimotor architecture and cannot be fully understood without referencing these bodily foundations, even when cognition operates offline and decoupled from direct environmental interaction. Shapiro and Stolz (2019) have argued persuasively that this framework has direct significance for education, though they caution that inferring prescriptive classroom practices from correlational embodied phenomena requires careful methodological translation.

3.2 Ecological and enactive perspectives

An ecological dynamics reading of physical literacy, articulated most forcefully by Rudd et al. (2020), reframes the construct away from a collection of acquired attributes and towards the functional, adaptive relationship between the individual and the environment. What matters is not merely whether a child can throw a ball with textbook form, but whether they can adapt their action to shifting task demands, perceive affordances, and exploit variability as a resource rather than a disturbance. This perspective finds resonance in the enactive approach developed in Italian physical education scholarship by Zambianchi and Scarpa (2020), who conceptualise reflexivity and self-formation as central to the educational relationship, and by Scarpa and Zambianchi (2022), who extend this enactive perspective specifically to the

pedagogy of motor and sport activities. These framings are not interchangeable (Wilson, 2002): grounded cognition retains a representational vocabulary that ecological and enactive accounts largely set aside, and the present proposal does not treat them as a single doctrine. For the purposes of assessment design, the ecological-dynamics reading does the principal work; grounded cognition and enactivism contribute more locally, the former to the rationale for body awareness, the latter to reflexive agency.

A tension should be acknowledged here. The phenomenological and monist orientation of physical literacy, rooted in Whitehead's (2001) reading of Merleau-Ponty's embodied subjectivity, sits uneasily alongside the psychometric tradition that dominates assessment development. Proposing to validate an embodied construct through confirmatory factor analysis and measurement invariance testing is not straightforwardly coherent. This paper does not resolve this tension; it names it as a live methodological question and proceeds with the working assumption that a multimethod approach combining performance tasks, self-report, and reflective prompts represents a defensible, if imperfect, compromise. Accordingly, the validation pathway proposed below should be read as an attempt to make selected dimensions observable for educational and research purposes, not as a claim that embodied experience can be exhaustively captured by psychometric indicators.

4. Existing assessment tools and unresolved gaps

The landscape of physical literacy assessment is rich in its coverage of some domains and thin in others. A domain-by-domain analysis reveals where the proposed architecture can draw on established instruments and where new development is needed.

Motor competence is the most extensively assessed domain. The CAPL-2 (Longmuir et al., 2018) remains a highly comprehensive multidomain battery for children aged 8–12, incorporating motor tasks alongside motivation, confidence, and knowledge questionnaires. The Delphi process underpinning the original model (Francis et al., 2016) provides a template for content validation. The broader landscape, however, reveals persistent difficulties: tools tend to be either process-oriented or product-oriented, rarely both, and none has achieved the robustness required for universal school screening (Eddy et al., 2020).

Self-perceived physical literacy is captured by instruments such as the PPLI (Sum et al., 2016), a tool originally validated for physical education teachers that includes self-confidence, self-expression, and knowledge dimensions, and PLAYself (Jefferies et al., 2021), which possesses good psychometric properties for youth self-report. These instruments address motivation and confidence effectively but do not extend to interoceptive or body awareness dimensions.

Body awareness and interoception represent a domain largely overlooked by physical literacy assessment. The MAIA (Mehling et al., 2012), refined in its second version (Mehling et al., 2018), provides a validated eight-factor framework with subscales including noticing, attention regulation, emotional awareness, self-regulation, body listening, and trust. The MAIA was neither designed for children nor integrated into physical literacy batteries. Developmental adaptation for children aged 8–11 would require simplification of items relying on abstract interoceptive vocabulary, reduction of the eight-factor structure to a shorter set of subscales appropriate for children's metacognitive capacities, and cognitive interviews to verify

comprehension. Such adaptation would be non-trivial and would require direct empirical testing of content validity and comprehension in the target age group.

Reflexive agency, the capacity to monitor, choose, narrate, and reinterpret one's own movement experience, lacks standardised assessment in the physical literacy literature. The concept is theoretically supported by research on self-regulated learning in physical education (Kolovelonis & Goudas, 2013), which draws on the four-level developmental model proposed by Zimmerman and Kitsantas (2005): observation, emulation, self-control, and self-regulation. Studies have shown that goal-setting, self-recording, and self-talk strategies enhance both motor performance and metacognitive awareness in primary-school physical education. The construct is theoretically informed by enactive scholarship on reflexivity and embodied self-formation (Zambianchi & Scarpa, 2020; Cereda, 2025), although its translation into a physical literacy assessment domain remains an original and exploratory step.

Relational participation—understood as cooperation, embodied communication, inclusion, and belonging through movement—is well supported by the cooperative learning literature in physical education. Casey and Goodyear (2015) conducted a systematic review demonstrating that cooperative learning robustly supports physical, cognitive, and social outcomes, whilst offering preliminary, albeit largely anecdotal, evidence for affective development. The five elements identified by Johnson and Johnson (2009)—positive interdependence, individual accountability, promotive interaction, interpersonal skills, and group processing—provide a clear theoretical framework. Gravino et al. (2023) report a small-scale Italian school-based study linking sport-based embodied activities with perceived school well-being, whereas Ciccarelli et al. (2024) offer a conceptual-methodological Italian proposal for embodied, gamified experiential teaching. The domain is conceptually coherent but lacks dedicated assessment tools within physical literacy frameworks.

5. Proposed architecture: six domains for the Index

The architecture proposed here organises the physical literacy component of the Index for Embodied Education around six domains. Each has a different degree of empirical maturity, and this asymmetry is deliberate: the first four domains are well supported, the latter two are more speculative.

The first domain, motor competence, concerns the quality, control, and adaptability of movement, drawing on CAPL-2 performance tasks and teacher observation. The second, body awareness, captures perception, interoception, and corporeal self-regulation, requiring developmental adaptation of MAIA-2 subscales. The third, motivation and confidence, encompasses pleasure in movement, perceived competence, and willingness to participate, drawing on the CAPL-2 questionnaire, PPLI, and PLAYself. The fourth, knowledge and understanding, addresses awareness of why, how, and when to move safely, building on CAPL-2 knowledge items and the expert-validated conceptual framework established by Francis et al. (2016).

Table 1 summarises the six-domain architecture and makes explicit how each domain contributes to the physical literacy component of the Index.

Table 1. Proposed six-domain architecture for the physical literacy component of the Index.

Domain	Embodied focus	Possible indicators	Assessment basis	Contribution to the Index
Motor competence	Action and adaptability	Movement quality, control, task adaptation	CAPL-2 tasks; teacher observation	Movement as embodied action
Body awareness	Perception and interoception	Noticing, attention regulation, body listening, self-regulation	Adapted MAIA-2 subscales	Corporeal awareness
Motivation and confidence	Affective engagement	Enjoyment, perceived competence, willingness to participate	CAPL-2 questionnaire; PPLI; PLAYself	Engagement in movement
Knowledge and understanding	Situated meaning	Knowing why, how, and when to move safely	CAPL-2 knowledge items; Delphi-informed framework	Reflective understanding
Reflexive agency	Self-regulation and narration	Choice, goal-setting, self-monitoring, reinterpretation	Reflective prompts; ipsative self-evaluation	Embodied reflexivity
Relational participation	Cooperation and belonging	Peer interaction, inclusion, communication, group processing	Teacher ratings; structured observation	Social embodiment

The fifth domain, reflexive agency, concerns the capacity to choose, monitor, verbalise, and reinterpret one's own movement experience. Built on the self-regulated learning literature in physical education (Kolovelonis & Goudas, 2013), this domain can be assessed through brief reflective prompts, ipsative self-evaluation tasks, and short-term goal-setting protocols. Its operationalisation remains preliminary and will require dedicated pilot work.

The sixth domain, relational participation, captures cooperation, embodied communication, inclusion, and belonging. It draws on the cooperative learning evidence base (Casey & Goodyear, 2015) and can be assessed through teacher ratings, peer interaction measures, and structured observation of cooperative movement tasks.

A multimethod structure is proposed. Block A (performance and observation) addresses motor competence through standardised tasks and teacher observation. Block B (multidimensional self-report) covers body awareness, motivation, knowledge, and, partly, relational participation through a questionnaire instrument. Block C (guided reflection) targets reflexive agency and, partly, relational participation through brief structured prompts designed to elicit self-monitoring, interpretation, and goal setting. In a pilot phase, domain scores would initially be computed with equal weights; subsequent analyses would test a bifactor model to determine whether a general 'embodied physical literacy' factor exists alongside specific domain factors. For educational use, the model should privilege domain profiles over a single classificatory score; a composite indicator may be useful for research only if empirical analyses demonstrate sufficient coherence across domains.

A clarification is essential. This model proposes the architecture for one component of the Index for Embodied Education, the physical literacy component. It does not claim to cover the full scope of embodied education, which necessarily includes dimensions of narrative, ethical reasoning, technological mediation, and inclusive practice that belong to other disciplinary traditions.

6. Operationalisation and validation pathway

The proposed target population is primary-school children aged 8–11. This range captures a developmental window extending from the consolidation of fundamental movement skills to their application in more complex, cooperative, and reflective practices. In the Italian system, it also intersects with the recent introduction of specialist physical education teaching in the upper years of primary school, especially grades IV and V, under Law No. 234/2021 (Legge 30 dicembre 2021). The choice is further motivated by the fact that several validated or partially adaptable instruments address adjacent age ranges, although any use in the Italian primary-school context requires careful cultural and developmental validation.

Phase 1 would include a Delphi panel comprising experts in physical literacy, embodied cognition, motor assessment, and primary-school pedagogy, tasked with evaluating the proposed domain structure, item relevance, and coverage. Cognitive interviews with teachers and children would follow to verify linguistic clarity and developmental appropriateness. A pilot study with a convenience sample of approximately 100–120 children would examine item distributions, floor and ceiling effects, administration time, and exploratory factor structure.

Phase 2 would employ confirmatory factor analysis in a larger sample, provisionally 400–600 participants; the final target would be determined a priori through model-based power analysis or Monte Carlo simulation, taking account of the number of items, estimated parameters, model complexity, and anticipated missingness. Reliability would be assessed through internal consistency (McDonald's omega) and test–retest stability. Measurement invariance would be tested across gender and age. Convergent validity would be examined against physical activity measures, motor competence (CAPL-2 motor tasks), self-efficacy, body awareness (adapted MAIA-2 subscales), and school well-being. Discriminant validity would be examined at the measurement level, where applicable, through latent-factor correlations and the heterotrait–monotrait ratio, with particular attention to overlap among reflexive agency, motivation, and knowledge. Incremental validity would be tested separately by determining whether reflexive agency and relational participation improve the prediction of engagement and participation beyond the four established domains, using hierarchical regression or nested structural models. Predictive validity would be assessed prospectively against engagement and participation trajectories. Alongside psychometric evidence, feasibility data should be collected to determine whether the framework can be implemented sustainably in school contexts.

6.1 Feasibility criteria for school implementation

For school implementation, psychometric quality is necessary but not sufficient. The framework should also be evaluated against feasibility criteria: total administration time; minimal disruption of physical education lessons; clarity of teacher instructions; acceptability for children; ease of scoring; and the capacity of results to inform pedagogical decisions rather than merely classify learners. These criteria should be assessed during pilot testing and considered part of the validation pathway.

Two scoring approaches merit investigation. Domain-specific profiles would provide formative information for educational use: a child's strengths in motor competence but lower reflexive agency, for instance, would guide differentiated

intervention. A research-oriented composite indicator, tested through bifactor modelling, would determine whether the six domains cohere around a common latent factor. Interpretive thresholds, if needed, should be established empirically and accompanied by clear guidance on ethical interpretation and communication to teachers, children, and families.

7. Educational implications

The architecture has consequences beyond measurement. For curriculum design, it implies that primary-school physical education should develop not only fundamental movement skills and fitness but also body awareness, reflective capacity, and cooperative participation. In practical terms, domain profiles could guide the design of learning units: tasks that vary affordances and constraints for motor competence; breathing, posture, and proprioceptive activities for body awareness; reflective prompts for agency; and cooperative games for relational participation. The specialist teacher introduced by Law No. 234/2021 creates a structural opportunity, the urgency of which is underscored by the Pediatric Inactivity Triad—physical illiteracy, exercise deficit disorder, and paediatric dynapenia (Faigenbaum et al., 2018)—a conceptual framework that reframes insufficient physical literacy not as an individual deficit but as a condition requiring concerted action across educational, clinical, and familial settings.

For teacher education, the model implies that future specialists in physical education and adapted physical activity should be trained to observe body awareness, recognise peer interaction quality, and facilitate reflective practice. In the Italian university context, this has direct implications for L-22, LM-67, and LM-68 degree programmes, where the integration of biomedical, pedagogical, and didactic knowledge is central to professional preparation. As argued elsewhere, developing this capability depends on epistemological beliefs that allow integration of biomedical and pedagogical knowledge (Cereda, 2026).

For the Index itself, the physical literacy component can intersect with other dimensions of embodied education through domains 5 and 6, which are intrinsically cross-cutting. A child's capacity to narrate their movement experience is simultaneously a physical literacy outcome and a narrative competence. These intersections are where the Index gains coherence. Finally, the model can support school-community partnerships by translating assessment results into shared educational goals across schools, families, sport organisations, and health-promotion services. In this sense, the physical literacy component of the Index is not only a measurement device but also a common language for coordinated action across the local community.

8. Limitations, open questions, and conclusion

Several limitations require explicit acknowledgement. The model is entirely conceptual: no empirical data are presented, and the proposed validation pathway has yet to be implemented. The six-domain architecture may prove excessively complex for routine school use, and the challenge of balancing comprehensiveness with practicability is not trivial. Domains 5 and 6 have a thinner empirical base than the others, and their operationalisation must be considered exploratory. The epistemological tension between the phenomenological orientation of physical

literacy and the psychometric framework of assessment development is not resolved here. It is named as a methodological frontier that future work might address through sequential mixed methods designs in which qualitative, phenomenologically grounded phases inform and contextualise quantitative measurement cycles. Further work is also needed on the ethical use of children's data, communication of results in non-stigmatising ways, and the professional development required for teachers to interpret domain profiles pedagogically.

Cross-cultural applicability remains untested. Whilst the CAPL-2 questionnaire has been successfully adapted for the Italian context (Iannaccone et al., 2025), the novel domains proposed here would require their own cultural validation. Whether the Index should produce a global score, domain scores, or a developmental profile is an open question that can only be settled empirically.

Despite these limitations, the central claim stands. Physical literacy, rethought through embodied cognition and ecological dynamics, can offer the Index for Embodied Education an operational architecture for assessing how children move, perceive, regulate, understand, narrate, and share embodied experiences. The architecture proposed here provides a starting point. The next step would be empirical: piloting items, testing structures, and iteratively refining the model in dialogue with the broader interdisciplinary community convened by the Stati Generali.

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