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Bakiak as Choreographic Code: An Embodied Computational Framework for Dance Pedagogy in Elementary Teacher Professional Learning

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Abstract
Generalist elementary teachers need ways to teach creative dance without reducing culture to display or technology to decoration. This conceptual article develops Bakiak as Choreographic Code, treating the Indonesian collective game as a materially coupled movement system whose shared footwear makes rhythm, balance, interdependence, disruption, and repair jointly consequential. A targeted integrative mapping of 34 peer-reviewed publications informed conceptual framework analysis and design synthesis. The resulting BAKIAK framework comprises six recursive processes: Read cultural movement patterns, Abstract movement principles, Code movement relations, Iterate through sensing and feedback, Articulate artistically as choreography, and Contextualize for elementary dance pedagogy. Computational thinking functions as reflective vocabulary rather than a model of dance, while micro:bit sensing remains sensor-informed, not sensor-determined. The contribution is a bounded, testable account linking cultural practice, embodied choreographic reasoning, physical computing, and teacher professional learning. Effectiveness is not claimed; staged empirical validation is specified carefully for subsequent empirical professional-learning studies.

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1. INTRODUCTION

Dance is a form of knowing in which thought is distributed across attention, sensation, timing, spatial organization, effort, interpersonal coordination, memory, and interpretation. For that reason, a dance lesson cannot be reduced to the transfer of visible movement from an expert body to a novice body. Research in dance education has long described movement as a nonverbal mode of imagining and learning (Hanna, 2008), while embodied-cognition scholarship explains why sensorimotor activity can participate in conceptual work rather than merely illustrate it (Barsalou, 2008; Wilson, 2002). The educational implication is precise: movement becomes intellectually consequential when bodily action is related to the problem being investigated, not when movement is added as a decorative break from thinking (Lindgren & Johnson-Glenberg, 2013; Skulmowski & Rey, 2018).

This position matters in elementary education because the teacher is rarely a specialist choreographer. A generalist teacher must make decisions that are both artistic and pedagogical: which movement problem is worth posing, how much structure a child needs, when imitation is useful and when it becomes restrictive, how safety is protected, how cultural material is contextualized, and how an exploratory task can be discussed after it has been performed. Work on creative dance shows that primary-level learning depends on a

productive tension between structure and learner agency (Chappell, 2007; Payne & Costas, 2021). Butterworth's process-continuum model further suggests that choreography teaching is not one fixed method but a shifting distribution of responsibility between teacher and learner (Butterworth, 2004). These findings point to a professional-learning problem rather than a simple repertoire problem. Teachers need ways to design movement inquiry, not merely additional dances to copy.

The present article approaches that problem through Bakiak, a traditional Indonesian group game in which several participants move together on shared wooden footwear. The proposal is not that Bakiak is already a dance, nor that its visible form should be staged as cultural spectacle. Its analytic value lies in material coupling. Several bodies are linked through a common locomotor interface, so one participant's timing, weight shift, hesitation, acceleration, or directional error immediately changes the conditions under which others can move. Sequence, common rhythm, synchronization, balance, communication, disruption, and repair therefore become group-level problems rather than merely parallel individual actions. Studies of Indonesian traditional games support their relevance to motor learning, fundamental movement skills, and social attitudes (Adi et al., 2022; Mujriah et al., 2022), but they do not establish a universal biomechanical taxonomy of Bakiak. The movement features used here are consequently treated as analytically derived design resources, bounded by the context in which the framework was conceived.

This material coupling is the specificity principle that justifies Bakiak as the starting practice. The claim is not that only Bakiak can generate choreographic problems of synchronization, dependence, or collective repair. Rowing, marching, group walking, and other cooperative practices may generate analogous relations. Bakiak is distinctive here because shared footwear compresses interdependence, timing, balance, and error propagation into one ordinary cultural action: locomotion succeeds only through negotiated collective coordination. The framework is therefore Bakiak-grounded rather than Bakiak-exclusive. Its propositions remain open to comparative testing against other coupled and non-coupled movement practices.

Reading Bakiak in this way creates an unusual connection with computational thinking (CT). CT has been described through practices such as decomposition, abstraction, sequencing, pattern recognition, algorithmic reasoning, iteration, and debugging (Grover & Pea, 2013; Hsu et al., 2018; Shute et al., 2017; Wing, 2006). Those practices can be recognized in choreographic work, although the relationship is analogical rather than ontological. A phrase may be decomposed; a motif may recur; an improvisational rule may take conditional form; a transition may be revised after it fails. None of this means that dance is software. Choreography remains aesthetic, affective, culturally situated, interpersonal, and open to ambiguity. CT is useful here because it gives non-specialist teachers a vocabulary for noticing how movement structures are made and remade.

The same need for conceptual restraint applies to technology. Micro:bit can connect motion to digital response through sensors, conditional rules, LEDs, and sound. Such physical-computing activity asks learners to move between real-world conditions, representations, system functions, and code (Cederqvist, 2022). In dance, that movement between contexts can support reflection. It cannot outsource artistic judgment. An accelerometer may register change in acceleration or orientation, but it cannot decide whether a phrase is compelling, culturally responsible, expressive, or pedagogically appropriate. Interactive-dance research similarly cautions that technology should support embodied knowledge, learning workflow, and collaborative making rather than flatten those practices into data alone (Ciolfi Felice et al., 2021; El Raheb et al., 2019).

A second restraint concerns culture. Culturally sustaining pedagogy asks education to do more than display cultural symbols; it asks educational practice to sustain and extend cultural and linguistic resources as living forms of participation (Paris, 2012). In this article, Bakiak is therefore not an ethnic label attached to a generic STEM activity. Its pedagogical value comes from the relational organization of bodies: moving together, negotiating tempo, depending on other bodies, and resolving collective disturbance. The framework is built around those relations while retaining an explicit warning that abstraction can decontextualize a practice if teachers ignore its social history, local meanings, and limits of interpretation.

The literature mapping undertaken for this article did not identify a publication that explicitly combines Bakiak as a generative choreographic code with embodied cognition, computational thinking, physical computing, culturally grounded dance pedagogy, and professional learning for elementary teachers. This is a bounded novelty claim, not a declaration of being the first work worldwide. The article therefore addresses three questions: (1) How can Bakiak be conceptualized as a generative choreographic code without equating cultural practice with choreography? (2) How can computational thinking and physical computing support embodied choreographic reasoning without reducing dance to algorithm or sensor data? (3) What professional-learning architecture follows from that conceptual integration for generalist elementary teachers? The resulting framework is intended as a testable design proposition. It organizes mechanisms, pedagogical actions, and evidence that later studies can validate, revise, or reject.

1.1 Embodied Cognition and Choreographic Reasoning

Embodied cognition is not a single theory, but its variants share a rejection of the assumption that cognition is exhausted by internal symbolic manipulation. Wilson (2002) and Barsalou (2008) describe cognition as grounded in perception and action systems, while educational accounts show that bodily engagement is most productive when it is integrated with the conceptual task (Lindgren & Johnson-Glenberg, 2013; Skulmowski & Rey, 2018). Henley (2021) brings this argument directly into dance education through 4E cognition—embodied, embedded, enacted, and extended—placing thinking within the moving person's relation to material, environment, and other bodies.

Choreographic reasoning can therefore be understood as reasoning that becomes visible through selection, sequencing, variation, spatial decision, timing, negotiation, and revision. Giguere's (2011) study of children's creative processes demonstrates that young dancers do not merely produce movement; they select, combine, test, negotiate, and evaluate ideas. An et al. (2021) similarly show how choreographic tasks can mobilize dynamic spatial reasoning among preservice elementary teachers. These studies help locate the central construct of the present framework: embodied choreographic reasoning is the capacity to form, test, and revise relationships among bodies, space, time, effort, and meaning through movement itself.

1.2 Creative Dance and Teacher Professional Learning

For a generalist teacher, creative dance is difficult not because creativity lacks value but because open-endedness must be designed. Chappell (2007) shows that primary dance creativity depends on negotiated spaces between teacher structure and pupil agency. Payne and Costas (2021) describe creative dance as active and experiential learning, while Butterworth (2004) makes explicit that teaching choreography involves changing roles and degrees of learner responsibility. These arguments shift professional learning away from the narrow question 'Can the teacher demonstrate the correct movement?' toward 'Can the teacher design conditions in which movement ideas can emerge, be examined, and be refined?'

Teacher education research supports that shift. Arts-based approaches can alter how teachers understand knowledge, identity, reflection, and lesson design (Møller-Skau & Lindstøl, 2022). More general research on professional development repeatedly emphasizes active learning, practice relevance, collaboration, feedback, and sustained opportunities for reflection (Avalos, 2011; Desimone, 2009). Recent dance-specific scholarship sharpens the point. Shen et al. (2026) identify instructional pedagogy and innovative, integrated dance pedagogy among the central dimensions of school dance-teacher competency, while Schwender et al. (2025) show how dance can function as embodied reflective practice within teachers' professional development. Together, these studies strengthen the rationale for a framework that develops pedagogical design capacity rather than repertoire acquisition alone.

1.3 Computational Thinking as Reflective Vocabulary

Computational thinking is often introduced through coding, but its educational meaning is broader than code production. Wing (2006) framed CT as a way of formulating problems and solutions through computational concepts. Subsequent syntheses organize the field around decomposition, abstraction, algorithms, sequencing, pattern recognition, iteration, and debugging (Grover & Pea, 2013; Hsu et al., 2018; Shute et al., 2017). Embodied approaches are especially relevant to this article because they position bodily action as part of the representation and manipulation of computational ideas. Kwon et al. (2024) showed that early-primary learners can engage CT concepts through embodied activity, and a later comparison found gains in CT knowledge across both mixed-reality and unplugged embodied conditions, with robot programming serving as a transfer task (Kwon et al., 2025). These findings do not validate dance as computation; they establish that CT concepts can be mediated through bodily activity without requiring programming to be the starting point.

The present framework uses CT cautiously. It does not ask teachers to force every dance process into formal computational categories. Instead, CT operates as a reflective vocabulary that can help teachers articulate processes already occurring in movement: dividing a complex phrase into learnable parts; identifying an invariant motif across variations; specifying a response to a change in tempo; repeating a phrase until a condition changes; or diagnosing why a collective transition fails. This embodied route is consistent with evidence that CT concepts can be mediated through movement in early primary education (Kwon et al., 2024). The sequence is intentionally bodily first and terminological second.

1.4 Culture, Physical Computing, and Epistemic Boundaries

The framework joins cultural practice and digital sensing, which creates a risk of conceptual overreach in two directions. The first is cultural: Bakiak could be emptied of context and reduced to a convenient set of movement constraints. The second is technological: a sensor could be granted authority over qualities it cannot measure. Recent evidence makes this boundary more, not less, important. A systematic review of 43 K-12 physical-computing studies describes sensors, actuators, and microcontrollers as hands-on systems for learning computing and related outcomes, while also noting the need for stronger comparative and longitudinal evidence (Vergara et al., 2025). In teacher education, micro:bit-based activity has also been associated with improvements in preservice teachers' self-perceived CT content knowledge and attitudes in mathematics education (Jeong & González-Gómez, 2026). Neither line of evidence warrants treating sensor output as artistic judgment or as direct evidence of dance-teaching competence.

Accordingly, this article adopts two boundary principles. First, culture functions as generative grammar rather than decoration: teachers study relations, rhythms, dependencies,

and collective problem solving rather than copying the visible game into a dance. Second, choreography is sensor-informed, not sensor-determined: sensors may make selected physical parameters available for discussion, but aesthetic, cultural, and pedagogical judgment remains human. These principles are not stylistic preferences. They define what the framework is allowed to claim.

2. RESEARCH METHODS

2.1 Analytic Position

This is a conceptual framework-development article, not an experiment, quasi-experiment, program evaluation, or systematic review. No participant dataset, pretest-posttest score, interview corpus, implementation cycle, or causal effect estimate is reported. The operative approach is conceptual framework analysis combined with design-oriented integrative synthesis. Design-based research (DBR) is not presented as a method already completed in this study. Rather, DBR provides a prospective trajectory for the next phase, when the framework can be enacted with teachers, examined in context, revised from evidence, and re-enacted across iterative cycles (The Design-Based Research Collective, 2003). This distinction prevents the present conceptual work from borrowing empirical authority from DBR stages that have not yet occurred.

Conceptual framework analysis supplied the main logic for synthesis. Following Jabareen (2009), the task was to identify constructs, examine their assumptions, determine where cross-domain analogies were defensible, and specify relations among them. The procedure therefore moved from problem framing and literature mapping to construct definition, functional analogy, boundary specification, and framework formulation. The result is a conceptual model with explicit propositions and evidence requirements, not an intervention whose effectiveness has already been demonstrated.

2.2 Design Context and Recontextualization

The design context originated in a community-service innovation that combined Bakiak with micro:bit-based learning activities for educators at Sekolah Indonesia Riyadh. The original program included face-to-face workshops, implementation, mentoring, and evaluation, with micro:bit, block-based coding, accelerometer sensing, LED output, and a buzzer. In this article those elements are treated as design resources, not as research results. The program did not generate evidence that the framework improves teachers' dance competence, and the manuscript does not retroactively construct such evidence.

Three recontextualization decisions were made. The target group was specified consistently as in-service elementary teachers. The principal outcome was changed from generic use of a culture-technology medium to the capacity to design dance pedagogy. Finally, technological language was narrowed: a sensor plus conditional code is described as physical computing and sensor feedback, not artificial intelligence. These decisions reduce category drift between the originating innovation and the conceptual article.

2.3 Targeted Integrative Literature Mapping

A targeted integrative mapping was used to construct the conceptual corpus. It was not designed to produce PRISMA-style claims of exhaustive coverage. Searches were organized around eight clusters: dance/choreography, embodiment, teacher professional learning, computational thinking, physical computing, interactive dance technology, culture/traditional games, and conceptual/design method. Search syntax was constructed in TITLE-ABS-KEY form compatible with Scopus. The bibliographic and source-level audit was updated on 25 August 2026, specifically to capture recent scholarship relevant to dance-teacher competency, embodied professional learning, embodied computational thinking, and physical computing.

The final corpus contained 34 peer-reviewed publications from 21 unique sources: 20 journals and one conference proceeding. Five publications dated 2025-2026 were incorporated in the final currency update: Shen et al. (2026) on school dance-teacher competency; Schwender et al. (2025) on dance as embodied reflective professional development; Kwon et al. (2025) on embodied computational thinking; Vergara et al. (2025) on K-12 physical computing; and Jeong and González-Gómez (2026) on micro:bit-supported CT learning in teacher education. Journal sources were audited at source level against SCImago/Scopus-linked records and bibliographic metadata were cross-checked against publisher or DOI records. The DIS 2021 conference paper was retained from the originating audit. This procedure is bibliographic quality control, not proof that the mapping is exhaustive or that database coverage is identical for every publication year. Table 1 reports the sources actually used by their principal conceptual function.

Table 1. Literature-mapping clusters and conceptual functions

Cluster and final sources	Example Scopus-compatible string	Selection focus
Dance/choreography (n=9)	TITLE-ABS-KEY(("dance education" OR choreograph*) AND (primary OR elementary OR teacher*))	Dance pedagogy, creativity, choreography, elementary teachers
Embodiment (n=4)	TITLE-ABS-KEY(("embodied cognition" OR "embodied learning" OR "4E cognition") AND education)	Body as medium of cognition and learning
Teacher learning (n=4)	TITLE-ABS-KEY(("teacher professional development" OR "professional learning") AND (arts OR pedagogy OR primary))	Active learning, reflection, practice-linked professional learning
Computational thinking (n=7)	TITLE-ABS-KEY("computational thinking" AND (embodied OR primary OR education))	Sequencing, abstraction, decomposition, iteration, debugging
Physical computing (n=3)	TITLE-ABS-KEY((micro:bit OR "physical computing") AND (education OR coding OR sensor*))	Sensing, coding, sense-react-act relation
Dance technology (n=2)	TITLE-ABS-KEY((dance OR choreograph*) AND ("interactive technolog*" OR digital OR sensor*))	Interactive systems, embodied workflow, choreographic reflection
Culture/traditional games (n=3)	TITLE-ABS-KEY(("traditional game*" OR "traditional sport*" OR Bakiak) AND (education OR teacher* OR movement))	Cultural pedagogy, movement, cooperation, traditional games
Conceptual/design method (n=2)	TITLE-ABS-KEY(("design-based research" OR "conceptual framework") AND education)	Design principles and framework-construction logic

Note. Counts indicate the primary conceptual function assigned to each source in the final 34-publication corpus; they are not raw database hit counts. Recent 2025-2026 sources were assigned to one primary cluster for counting even when they informed more than one conceptual relation.

Inclusion required direct relevance to at least one conceptual cluster, peer-reviewed publication status, a verifiable DOI and bibliographic record, and a theoretical or empirical contribution needed to specify relations among constructs. Duplicates, non-peer-reviewed sources, items without verifiable DOI metadata, and publications that mentioned a keyword only peripherally were excluded. Additional items were not retained once conceptual saturation was reached for the specific relation under construction. These criteria are appropriate for framework building, but they do not justify an exhaustive-review claim.

2.4 Conceptual Synthesis Protocol and Claim Control

The synthesis proceeded through six operations. First, recurring mechanisms and practices were extracted within each literature cluster. Second, functional analogies were mapped across domains, such as sequencing in computation and ordering in movement composition. Third, the Bakiak design context was read for observable relational movement problems rather than for a universal biomechanical taxonomy. Fourth, cross-domain relations were translated into actions that an elementary teacher could perform. Fifth, epistemic boundary checks were applied: CT could not become a claim that dance is computation, sensor values could not become aesthetic judgments, and cultural abstraction could not erase context. Sixth, the BAKIAK cycle, professional-learning sequence, competencies, and empirical validation agenda were assembled as a coherent design proposition.

Figure 1 summarizes this logic. The sequence shown in the diagram represents analytic development rather than causal effects. It traces how the article develops a testable framework from a cultural movement practice through analytical reading and theoretical synthesis.

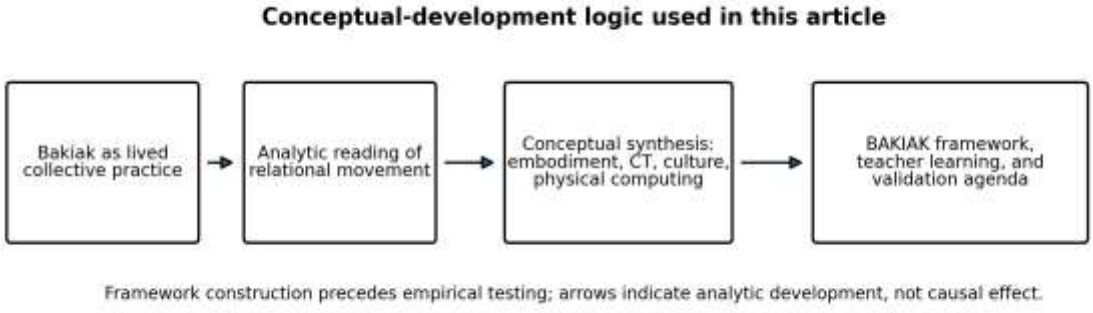


Figure 1. Conceptual-development pathway from Bakiak practice to a testable teacher-learning framework.

3. RESULTS AND DISCUSSION

3.1 Research Results

3.1.1 Bakiak as a Materially Coupled Relational Movement System

The conceptual shift begins with the pedagogical question. Asking 'How can Bakiak be inserted into a dance?' directs attention toward literal representation. Asking 'What relations must bodies organize for collective movement to occur, and how can those relations be transformed choreographically?' directs attention toward a generative problem. In Bakiak, the shared boards matter because they materially couple participants: timing, force, balance, direction, and hesitation are not private variables. A mismatch in one body propagates into the movement conditions of the others. The resulting analytic phenomena include ordered stepping, collective pulse, synchronization, transfer of weight, balance, directional orientation, response to perturbation, and collective correction. These are not proposed as a universal taxonomy of every Bakiak practice. They are a bounded reading of the relational demands that the shared artifact makes salient in the design context.

The phrase choreographic code refers to the generative use of relations and constraints. A code in this sense is not software. It is a compact set of rules that can be detached from the literal object and used to produce different movement possibilities. A shared pulse might become a constraint for three dancers who never perform identical steps; a disturbance rule might require one dancer's directional change to reorganize the group; an error-repair pattern might become the dramatic logic of a phrase. The Bakiak specificity principle lies in the combination of cultural location and material coupling, not in a claim of exclusive uniqueness. Other movement practices may generate similar choreographic relations, which is why comparative testing is part of the empirical agenda. What this framework asserts is narrower: Bakiak offers a culturally situated, materially legible instance in which collective locomotion depends on negotiated interdependence.

3.1.2 The BAKIAK Embodied Computational Choreography Framework

Table 2. BAKIAK Embodied Computational Choreography Framework

Stage	Core activity	Reflective question	Primary output
B – Read cultural movement patterns	Experience and observe Bakiak as a relational bodily event.	What must bodies coordinate for the group to move?	Map of movement phenomena
A – Abstract movement principles	Separate relational principles from the literal equipment or visible game form.	What remains important when the physical Bakiak is removed?	Principles: rhythm, balance, synchronization, response
K – Code movement relations	Specify sequences, repetitions, conditions, roles, and transformation rules.	How can the principle be written or demonstrated as a movement rule?	Choreographic score / rule set
I – Iterate through sensing and feedback	Try, observe, read peers or sensor information, revise, and try again.	Which relation is failing to match the artistic or pedagogical intention?	Revised movement version
A – Articulate artistically as choreography	Shape space, time, effort, level, formation, transition, canon, unison, and contrast.	How does the logic become dance rather than a replica of the game?	Motif, phrase, short composition
K – Contextualize for elementary dance pedagogy	Translate the experience into learning goals, instructions, scaffolds, safety, assessment, and reflection.	How can children encounter the problem safely, creatively, and with cultural context?	Lesson/activity design

The framework is cyclic rather than linear. Contextualization may expose an unsafe instruction, a movement task that is too cognitively dense, or an outcome that simply mimics the original game. When that happens, the teacher returns to reading, abstraction, or coding and changes the rule before proceeding. Iteration is therefore a property of the entire framework, not only of the fourth stage.

The six stages are organized around embodied choreographic reasoning. Culture, computational thinking, physical computing, and professional learning do not appear as

separate add-ons; they constrain what the central reasoning process can legitimately do. Figure 2 visualizes that relationship.

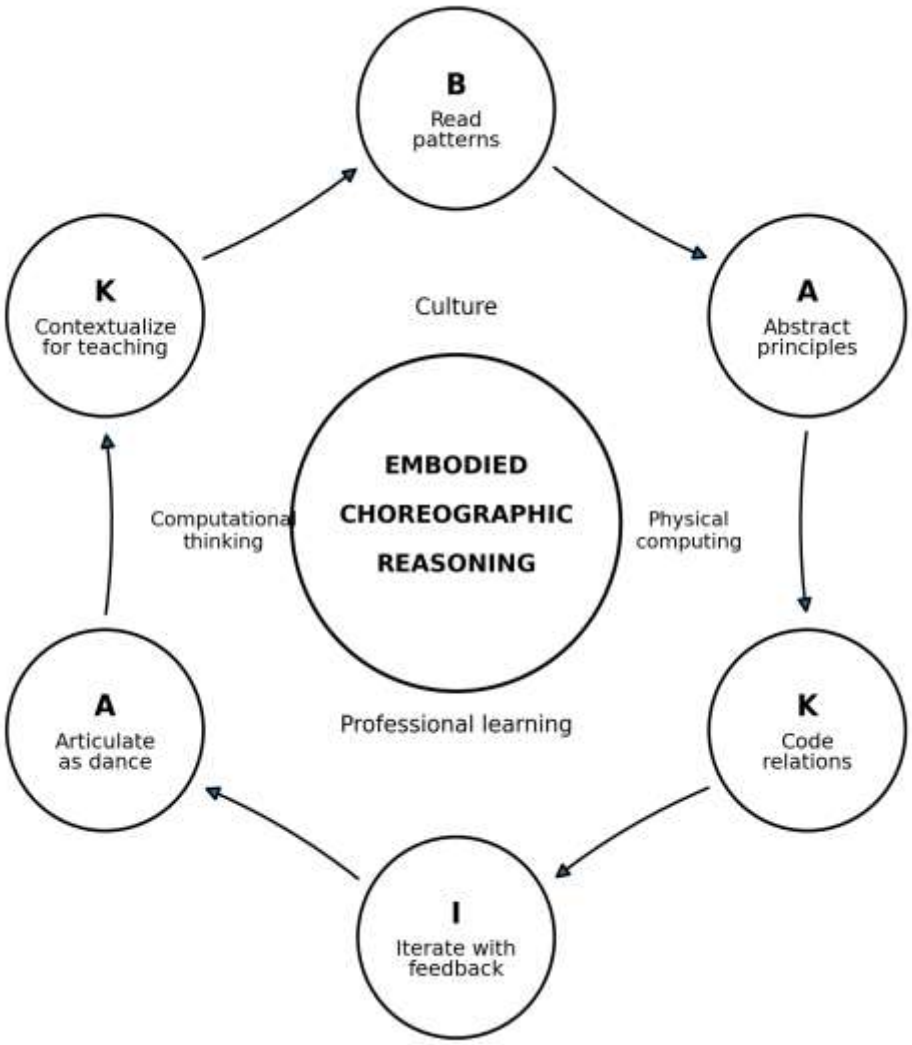


Figure 2. The BAKIAK cycle with embodied choreographic reasoning at its conceptual center.

3.1.3 From Computational Thinking to Choreographic Thinking

Table 3. Functional mapping between relational movement, computational thinking, and choreography

Bakiak-derived phenomenon	CT concept	Choreographic transformation	Question for the teacher
Ordered steps	Sequencing	Arrange motifs A–B–C and transitions	What changes if the order is reversed?
Recurring pattern	Loop / repetition	Repeat a phrase, create bodily ostinato, vary recurrence	When should repetition stop or mutate?
Coordination problem divided into parts	Decomposition	Break a phrase or group relation into learnable units	Which part must be stabilized first?

Bakiak-derived phenomenon	CT concept	Choreographic transformation	Question for the teacher
Pattern recognized across variation	Pattern recognition	Identify an invariant motif and its transformations	What remains recognizable when space or tempo changes?
Principle detached from equipment	Abstraction	Preserve relational essence without copying the game	How can collectivity remain without literal Bakiak form?
Group adapts to change	Conditional logic	Use if–then rules for constrained improvisation	If the tempo changes, what must the group do?
Mismatch between intention and execution	Debugging	Diagnose and revise a transition, relation, or timing problem	Why is this passage not working as intended?
Solution tested again	Iteration	Rehearse–observe–revise–rehearse	What changed between versions, and why?

Note. The mappings are functional analogies. They do not assert that choreography and computation are ontologically equivalent.

Choreographic debugging is a particularly useful operational term. In programming, debugging identifies why a system fails to behave as intended and alters the system. In choreography, the object of diagnosis is not technical correctness alone. The teacher compares an intention with an embodied event: a unison collapses, a spatial pathway becomes unreadable, a transition loses momentum, a rule overconstrains improvisation, or the cultural idea of collective dependence disappears. Debugging then becomes disciplined artistic inquiry. More than one revision can be acceptable.

This distinction matters for teacher learning. CT terms can make movement-making processes discussable without dictating what the final dance must look like. The vocabulary is a scaffold for attention. It is not a scoring algorithm for artistic worth.

3.1.4 Physical Computing: Sensor-Informed, Not Sensor-Determined Choreography

Micro:bit is positioned as a physical-computing device that can connect bodily action with a simple programmed response. An accelerometer can register changes in acceleration or orientation, after which a threshold or conditional rule can trigger an LED pattern or a sound. At this level, sensing occurs first, the programmed rule compares or interprets the input, and the device then produces a response. Cederqvist (2022) shows that micro:bit activity requires movement among real-world conditions, representations, system functions, and code. More recent synthesis confirms that physical-computing interventions in K-12 education are typically hands-on and collaborative but remain heterogeneous in their assessment and evidence base (Vergara et al., 2025). Jeong and González-Gómez (2026) further demonstrate the relevance of micro:bit to teacher learning in a different subject domain, while not providing direct evidence for dance pedagogy. These sources support the device category and learning logic; they do not validate the artistic claims of this framework.

In a dance workshop, a teacher might use a sensor to flag when movement intensity crosses a threshold, to register repeated changes in orientation, or to prompt a transition after a specified event. The pedagogical cycle begins with movement, proceeds through sensing, reading, and interpretation, and then returns to movement after reflection and revision.

Crucially, the interpretation remains embodied and social. Sensor output can focus attention on a selected parameter; it cannot determine whether the movement is aesthetically convincing or culturally appropriate. This is the meaning of sensor-informed, not sensor-determined choreography.

The boundary also prevents a common terminology problem. A microcontroller running conditional rules from sensor input should not be described as artificial intelligence unless an actual AI model or learning system is present. The conceptual contribution of this framework does not depend on an inflated technology label. Its interest lies in how physical computing reorganizes observation and reflection inside a choreographic task.

3.1.5 Professional-Learning Architecture for Elementary Teachers

The professional-learning design follows a simple premise: teachers should encounter the reasoning process before they are expected to teach it. This aligns with professional-development literature emphasizing active engagement, practice relevance, collaboration, feedback, and reflection (Avalos, 2011; Desimone, 2009), with primary dance work emphasizing direct experience and culturally responsive pedagogical support (Melchior, 2011), and with newer scholarship that frames dance professional development as embodied reflective practice (Schwender et al., 2025). The recent review by Shen et al. (2026) is also significant because it identifies dance-teacher competency as multidimensional, combining subject knowledge with instructional, innovative, integrated, empowering, and inclusive pedagogical capacities. The BAKIAK sequence is therefore designed as professional reasoning practice rather than as a one-way seminar about dance or technology.

The proposed sequence begins with bodily difficulty. Teachers experience coordination, dependence, timing, and breakdown. Only after those events are available for reflection are computational terms introduced. The sequence then removes the physical Bakiak, turns relations into movement constraints, uses sensing selectively, develops short choreography, and finally translates the experience into an elementary lesson. The process is deliberately reversible; a failed pedagogical task can send teachers back to artistic abstraction rather than forcing them to protect a flawed lesson plan.

3.1.6 Six-Session Professional-Learning Sequence

Table 4. Proposed six-session BAKIAK professional-learning sequence

Session	Teacher activity	Evidence/output
1. Experience Bakiak	Play/explore; document rhythm, balance, synchronization, communication, and breakdown.	Embodied experience journal
2. Read movement as a system	Map input–relation–action–response–correction; identify sequence, pattern, and decomposition.	Relational movement map
3. Abstract and choreographically code	Remove equipment; construct motifs and scores using sequence, repetition, condition, canon/unison, and role relations.	Movement score and phrase
4. Sense and iterate	Use micro:bit/accelerometer only for selected physical parameters; conduct revision loops.	Choreographic debugging record
5. Articulate artistically	Shape space, time, effort, level, formation, transition, contrast, and cultural meaning.	Short composition

Session	Teacher activity	Evidence/output
6. Translate pedagogically	Design objectives, instructions, scaffolds, safety, assessment, reflection, and microteaching for elementary learners.	Lesson/activity module + microteaching

3.1.7 Target Competencies and Evidence

Table 5. Competencies targeted by the BAKIAK framework

Competency	Operational definition	Initial indicator	Possible evidence
Movement literacy	Read bodily and relational movement phenomena.	Identifies space, time, effort, rhythm, balance, and interdependence in a movement event.	Annotated observation + movement map
Choreographic reasoning	Organize material into an intentional artistic structure.	Builds motifs, phrases, transitions, formations, canon/unison, and meaningful variation.	Score, rehearsal video, short composition
Embodied computational thinking	Use sequence, pattern, abstraction, condition, iteration, and debugging through movement.	Translates a movement problem into rules that can be tested and revised.	Rule set + revision trace
Physical-computing literacy	Use sensing and digital output proportionally.	Connects sensor input to simple rules and interprets feedback without treating it as aesthetic judgment.	Program + sensor log + reflection
Cultural pedagogy	Maintain context and ethical attention during creative transformation.	Explains the practice source, collective values, limits of interpretation, and risks of decontextualization.	Context note + reflective justification
Elementary dance-pedagogy design	Translate creative experience into developmentally appropriate learning.	Formulates goals, scaffolds, safety, open constraints, assessment, and reflection.	Lesson design + microteaching

These competencies are intentionally plural. A technically correct micro:bit program does not demonstrate choreographic reasoning; an inventive movement phrase does not by itself demonstrate culturally responsible pedagogy. The professional-learning design should therefore collect multiple forms of evidence rather than collapse competence into a single test score.

Assessment can remain formative in early implementations. Facilitators can compare successive movement versions, examine teachers' justifications for revisions, observe whether sensor evidence is interpreted proportionally, and evaluate how teachers transform their own embodied experience into instructions suitable for children. Such evidence is better aligned with the framework's mechanism than a stand-alone self-efficacy questionnaire, although quantitative measures may later complement the design.

3.1.8 Testable Propositions Generated by the Framework

Table 6. Testable propositions generated by the framework

Proposition	Claim	Empirical route
P1. Materially coupled cultural generativity	Bakiak becomes a generative choreographic resource when teachers abstract relational principles from its materially coupled locomotion while retaining explicit cultural-context reflection, rather than reproducing visible game form.	Compare Bakiak-based relation tasks with literal-reproduction tasks and with a non-coupled cooperative movement task; analyze movement diversity, interdependence, cultural reasoning, and repair strategies.
P2. Embodied-first CT	CT vocabulary is more likely to support novice teachers' choreographic reasoning when computational concepts are named after bodily experience and used to organize reflection rather than introduced as formal categories before movement.	Contrast embodied-first and terminology-first professional-learning sequences; examine transfer to lesson design.
P3. Sensor-informed iteration	Physical computing supports reflective revision when sensor information is restricted to selected physical parameters and remains subordinate to human artistic and cultural judgment.	Analyze revision episodes with and without sensor feedback; code whether sensor data opens or narrows artistic decision-making.
P4. Cyclic professional learning	Teacher design capacity is strengthened when professional learning cycles through experience, abstraction, coding, sensing, artistry, and pedagogical contextualization with opportunities to return to earlier stages.	Track competence change and revision trajectories across repeated workshops and microteaching.

3.2 Discussion

3.2.1 The Body as an Epistemic Site

The first theoretical contribution is the ordering of knowledge. Many CT integrations begin with a list of concepts and search for activities that instantiate them. The BAKIAK framework reverses that sequence. Teachers first experience a coordination problem, encounter failure, notice recurring relations, and try a solution. Only then do terms such as decomposition, sequence, condition, or debugging become available. The proposed pathway is bodily experience, then conceptualization, then computational representation, then choreographic transformation, then pedagogical design. This ordering gives embodied cognition an architectural role rather than citing it as background theory.

The reversal also matters for dance. Choreographic knowledge is partly tacit and relational. A teacher may understand why three bodies cannot sustain a shared rhythm before being able to explain the problem verbally. Professional learning should not treat that pre-verbal knowledge as an obstacle to be replaced by terminology. It is the material from which useful terminology can emerge.

3.2.2 Culture as Generative Grammar, Not Decoration

The second contribution is a change in what counts as cultural integration. A traditional object can easily become a visual sign of identity while the social organization of the practice disappears. BAKIAK instead asks what the practice requires bodies to negotiate. Its strongest theoretical justification is material coupling: the shared boards make dependence visible and consequential because collective locomotion cannot be achieved through several independent solutions performed side by side. This does not make Bakiak the only practice capable of generating such relations. It makes Bakiak a particularly compressed cultural case through which interdependence, rhythm, balance, disruption, and repair can be converted into choreographic questions while remaining accountable to the source practice.

This move is productive but ethically unstable if it is treated as permission to abstract without limit. Cultural practices are not neutral design libraries. Teachers need to identify the source practice, discuss why collective movement matters in that practice, and ask what is lost when equipment, setting, or social function is removed. Culturally sustaining pedagogy provides a useful standard because it directs attention to continuity, participation, and living cultural resources rather than to symbolic inclusion alone (Paris, 2012).

3.2.3 Computational Thinking as a Language for Artistic Inquiry

The third contribution lies in the use of CT as language rather than ontology. Abstraction, decomposition, iteration, and debugging are already recognizable in creative processes, yet generalist teachers may lack concise terms for discussing them. Naming those processes can improve metacognitive access to choreography. The gain is not that dance becomes more computational; the gain is that teachers can describe the architecture of their own decisions and make that architecture available for pedagogical design.

The framework therefore resists algorithmic closure. A debugging episode in choreography does not search for one technically correct answer. It asks why a relation is not producing the intended experience and what other choices might restore or revise that intention. Ambiguity remains legitimate. That point protects dance from the common interdisciplinary error in which a borrowed vocabulary silently becomes the standard by which the host discipline is judged.

3.2.4 Technology as a Reflective Partner

The fourth contribution is terminological and epistemic restraint. Sensor systems are often attractive because they appear objective. Yet objectivity at the level of a measured physical parameter does not transfer automatically to artistic interpretation. A motion threshold may be measured consistently while the meaning of crossing that threshold remains open. El Raheb et al. (2019) and Ciolfi Felice et al. (2021) show why interactive systems for dance have to be understood within teaching and choreographic workflow, not apart from it.

Calling the device a reflective partner captures the intended role. It can make movement noticeable in a new way, record a trace, or provoke a question. It cannot settle the question. That division of labor is especially important in teacher professional learning, where a technically impressive device can otherwise distract from the central pedagogical work of designing movement problems and interpreting children's responses.

3.2.5 From Demonstrator to Designer of Movement Problems

For elementary teachers, the practical significance of the framework is a role change. A demonstration-imitation model positions the teacher as the source of a correct form and pupils as bodies that reproduce it. BAKIAK positions the teacher as a designer of movement problems. The teacher specifies constraints that are observable but not overdetermined, then supports children as they notice, choose, negotiate, revise, and explain movement.

Consider the task: 'How can three people travel from point A to point B while maintaining one shared pulse but without using identical movements?' The problem has enough structure to be discussable—destination, pulse, relation, difference—yet no single movement answer is required. A teacher can help children decompose the task, test sequences, recognize patterns, and revise coordination without turning the lesson into a computer-science lecture. The CT language remains primarily for teacher reasoning; children can encounter the logic through action.

3.2.6 Claim Boundaries

The novelty claim is intentionally narrow. The article does not claim that Bakiak has never been used in education, that technology is new to dance education, that embodied learning and CT have not previously been connected, or that Bakiak is the only cooperative practice capable of generating interdependent movement. The contribution is the configuration and its specificity principle: Bakiak is treated as a culturally situated, materially coupled generative choreographic code that links embodied cognition, computational thinking, sensor-based physical computing, and elementary-teacher professional learning in one pedagogical cycle. The 2025-2026 literature update strengthens the surrounding evidence base but does not remove the need to test whether the Bakiak-derived mechanism adds explanatory or pedagogical value beyond other cooperative movement practices.

That configuration remains a conceptual proposition. The targeted mapping cannot establish the absolute absence of similar work worldwide, and the framework has not yet been shown to improve teaching, choreography, CT, or cultural understanding. Stating these limits is not a weakness to be repaired rhetorically; it is part of the framework's scientific specification.

3.3 Empirical Validation Agenda and Limitations

3.3.1 Staged Validation

The next research phase should begin with construct and content validity rather than a large effectiveness trial. Expert review should include dance education, elementary pedagogy, Indonesian cultural/traditional-game knowledge, computational thinking, and learning technology. Reviewers should examine not only clarity but construct separation: whether CT language is genuinely serving choreographic reasoning, whether the cultural abstraction is defensible, and whether sensor use is proportionate.

A small feasibility workshop with elementary teachers should follow. The purpose would be to identify where teachers misunderstand the six stages, where movement tasks create safety or access problems, and whether the professional-learning sequence is feasible within real school constraints. Evidence should include video of movement-making, reflective journals, choreographic scores, lesson designs, microteaching, and sensor/program logs where technology is used. Multimodal data are necessary because the framework concerns both embodied process and pedagogical translation.

Only after revision should a more formal implementation study examine change in the six competencies from Table 5. A mixed-method design could combine rubric-scored products and observations with teacher interviews, reflection data, and carefully selected CT or technology measures. Comparative or quasi-experimental designs would become meaningful after the intervention itself has stabilized. An early randomized comparison of an underdeveloped framework would produce a precise answer to the wrong question.

3.3.2 Limitations

First, the framework is conceptual and has no causal or effectiveness evidence. Its current scientific value lies in the explicit organization of constructs, mechanisms, boundary conditions, and testable propositions.

Second, the literature procedure was a targeted integrative mapping rather than an exhaustive systematic review. The corpus was updated through 25 August 2026 and includes recent 2025-2026 work, but novelty claims still apply only to the mapped corpus and search strategy, not to all publications in every language and database.

Third, Bakiak is a culturally situated practice. Transforming its relational logic into choreography can create decontextualization if teachers do not address source, social meaning, local variation, and limits of interpretation.

Fourth, micro:bit sensing captures only selected physical parameters. It cannot measure aesthetic quality, expressivity, cultural meaning, group trust, or the pedagogical appropriateness of a movement choice.

Fifth, the framework was designed for professional learning of in-service elementary teachers. Adaptation for preservice teachers, specialist dance educators, professional dancers, or other school levels should be treated as a new design problem rather than assumed to transfer unchanged.

Sixth, DBR has not yet been conducted as an empirical method for this framework. It is specified only as the prospective enactment-and-redesign trajectory for future studies. Claims about iteration, feasibility, or refinement must therefore wait until implementation cycles with teachers have been completed and documented.

4. CONCLUSION

Bakiak as Choreographic Code relocates a traditional game from the position of cultural material to be displayed toward a source of relational movement problems that can generate choreography. Its analytic specificity lies in materially coupled locomotion: shared footwear makes rhythm, balance, interdependence, disruption, and repair jointly consequential. The six-stage BAKIAK cycle asks teachers to read a cultural movement practice, abstract its relational principles, code movement relations, iterate through embodied and sensor-informed feedback, articulate those relations artistically, and contextualize the result as elementary dance pedagogy.

The framework's contribution is not technological novelty and not a claim that choreography is computation. Its contribution is a disciplined connection among embodied cognition, choreographic reasoning, computational thinking, physical computing, cultural pedagogy, and teacher professional learning. Micro:bit is deliberately limited to the role of reflective partner. Sensor output can inform attention; it does not judge artistic or cultural value.

The framework now requires evidence. Expert validation, feasibility work, multimodal analysis of teacher movement-making, microteaching, and iterative redesign should precede claims of effectiveness. If those stages support the conceptual propositions, Bakiak may offer more than a heritage object introduced into school. It may become a rigorous source of embodied reasoning through which teachers learn to design contemporary, culturally accountable, and creatively open dance experiences for children.

5. DECLARATIONS

Ethics statement. Not applicable at the present conceptual-development stage because no human-participant research data are reported in this article.

Data availability. No empirical dataset was generated or analyzed for this conceptual framework article.

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