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A Video-Based Movement Coding Framework for Analyzing Embodied Scaffolding in Preschool Ballet Learning

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SUMMARY: *Preschool ballet learners often experience spatial instability and fragmented movement regulation when structured dance tasks exceed their developing sensorimotor capacities. Although scaffolding theory provides a useful lens for understanding assisted learning, less is known about how embodied scaffolds support movement regulation and how such support can be traced through video-based observation. This study proposes a video-based movement coding framework for analyzing embodied scaffolding in preschool ballet learning. Using a qualitative microgenetic single-case design, the study followed a six-year-old ballet learner, Leo, across an eight-week intervention. Video recordings of diagonal walking tasks were segmented into movement episodes and analyzed through an adapted Laban Movement Analysis-informed framework. The findings suggest that different forms of scaffolding supported different aspects of Leo's movement regulation. Physical scaffolds, such as floor markers, helped stabilize spatial pathways by providing external visual anchors. Metaphorical prompts redirected attention from isolated body parts toward whole-movement intention. Peer synchronization supported rhythmic continuity by offering a moving social reference. During scaffold fading, Leo gradually relied less on explicit environmental cues and showed signs of emerging proprioceptive regulation. Reductions in coded movement disruptions, including unstable spatial support and directional inconsistency, indicate that the framework can capture process-level changes in embodied movement learning. The study contributes a process-oriented analytic approach for examining scaffolded movement regulation and internalization in early childhood dance education.*

KEYWORDS: *movement coding; preschool ballet learning; multimodal analysis; embodied cognition; scaffold fading*

1 Introduction

1.1 Preschool Movement Learning and Spatial Regulation

Early childhood movement learning is often marked by a tension between children's strong willingness to move and their still-developing capacity for bodily regulation. In preschool ballet, this tension becomes especially visible in structured locomotor tasks such as diagonal walking, where children are expected to coordinate spatial direction, weight transfer, rhythm, posture, and attentional focus at the same time.

For young learners, these difficulties should not be understood simply as lack of effort or

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inattentiveness. Rather, they often reflect the developmental challenge of organizing perception, movement, and environmental information within a highly structured dance form. Research on motor competence emphasizes that children's movement development is shaped by the interaction of biological, psychological, instructional, and environmental constraints over time, rather than by age alone.

In ballet learning, this developmental complexity becomes clear when children attempt to maintain a pathway across space. A child may understand the teacher's instruction and imitate the general form of the movement, yet still drift away from the intended route, lose rhythm, or allow upper- and lower-body coordination to separate. Such instability suggests that spatial regulation is not merely a technical skill, but an embodied process involving attention, balance, timing, and environmental reference.

This study takes this issue as its starting point. It focuses on how a preschool ballet learner gradually developed more stable movement regulation through scaffolded interaction with physical markers, metaphorical language, peer movement, and the gradual withdrawal of support.

1.2 Scaffolding as Embodied Regulation

Scaffolding theory provides a useful lens for understanding how children move from assisted performance toward greater autonomy. Vygotsky's concept of the Zone of Proximal Development explains learning as a socially mediated process in which children can perform beyond their independent level when appropriate support is available (Vygotsky, 1978). Wood et al. (1976) later described scaffolding as temporary assistance that helps learners manage task demands until they can act with greater independence.

In movement-based learning, however, scaffolding cannot be limited to verbal explanation or teacher correction. Dance learning is bodily, spatial, rhythmic, and relational. Support may therefore take the form of a floor marker that makes direction visible, a metaphor that reorganizes attention, or a peer whose movement provides a rhythmic reference. In this sense, scaffolding functions as a temporary external regulatory structure rather than merely as instructional help.

This position is consistent with embodied cognition theory. Shapiro (2019) presents embodied cognition as a major approach in cognitive science that challenges the separation of mind and body, while Macedonia (2019) argues that school learning often remains overly mentalistic and that the body plays a central role in learning processes. For preschool ballet learners, this means that spatial understanding and movement control are not acquired only through verbal instruction; they emerge through repeated bodily engagement with the learning environment.

From this perspective, embodied scaffolding can be understood as a process in which external supports temporarily organize perception and action. Over time, these supports may be reduced, allowing the learner to rely more on internal bodily awareness and proprioceptive regulation.

1.3 Video-Based Multimodal Observation and Movement Coding

To understand how embodied scaffolding works in preschool ballet learning, movement needs to be examined as it unfolds, rather than only through final performance outcomes. General classroom observation can describe whether a child completed a task, but it is less able to show when spatial instability appears, how attention shifts, or how a scaffold changes the child's movement response.

Recent work on embodied educational technologies has shown that learning can be studied through multiple modes of interaction, including gesture, body movement, spatial positioning, talk, and action with objects (Walkington et al., 2024). Similarly, Aloizou et al. (2025) demonstrate that movement-based and multimodal learning activities can be systematically integrated into authentic kindergarten classrooms through careful learning design. Although their study focuses on immersive learning platforms rather than dance pedagogy, it supports the broader methodological point that movement, interaction, and classroom design need to be analyzed together in early childhood learning contexts.

The present study follows this direction without using immersive technology or motion-capture systems. Instead, it treats classroom video as the main source for process-oriented movement analysis. Video makes it possible to revisit movement episodes repeatedly and observe details such as pathway deviation, gaze shifts, pauses, timing changes, peer synchronization, and dependence on scaffolds. This allows the analysis to move beyond the question of whether Leo improved and toward the question of how movement regulation changed across the intervention.

Laban Movement Analysis provides a useful conceptual foundation for this coding process because it offers a vocabulary for describing movement in terms of space, time, body organization, and dynamic quality (Newlove & Dalby, 2004). However, this study does not use formal Labanotation. Instead, it develops an adapted LMA-informed coding framework for preschool classroom observation. This distinction matters because preschool movement is often variable, emergent, and incomplete. The purpose is not to judge ideal ballet technique, but to trace changes in spatial support, directional control, rhythm, and scaffolded movement regulation over time.

1.4 Current Research Limitations

Taken together, the literature suggests that embodied learning, movement-based education, and dance pedagogy have begun to move toward a more process-oriented understanding of children’s learning. However, several limitations remain.

First, much of the existing early childhood dance research still discusses dance learning through broad outcomes such as creativity, engagement, expression, or curriculum design. These topics are important, but they do not fully explain how children organize movement while performing structured dance tasks. In particular, the small changes that occur during movement—such as pathway drift, pauses, gaze shifts, rhythm breaks, or delayed correction—are often left underexamined.

Second, scaffolding research has been more fully developed in language, cognition, and problem-solving contexts than in bodily learning. When the learning difficulty is spatial and motoric, support does not only come from explanation or feedback. It may also come from the floor, the visual field, the teacher’s metaphor, or the movement of another child. How these different forms of support work together in preschool dance learning still requires closer analysis.

Third, scaffold fading remains insufficiently studied in movement-based contexts. Although fading is central to scaffolding theory, we know less about what happens when physical markers, verbal prompts, or peer support are gradually removed. It is still unclear how a child maintains, loses, or reorganizes bodily control during this transition.

Finally, dance education research lacks classroom-usable coding tools that can describe preschool children’s movement regulation with enough specificity. Professional notation systems may be too complex for ordinary classroom research, while general observation notes often miss the movement details that matter. This creates a methodological gap between rich classroom experience and systematic movement analysis.

These gaps point to the need for a video-based, process-oriented approach that can connect embodied scaffolding, movement coding, and preschool ballet learning.1.5 Research

Purpose and Questions

This study develops and applies a video-based movement coding framework to examine embodied scaffolding in preschool ballet learning. The focus is not on judging ballet technique as a final product, but on tracing how movement regulation changes over time.

The study follows Leo, a six-year-old ballet learner, across an eight-week intervention. The analysis focuses on diagonal walking tasks because they make spatial regulation, rhythm, attention, and body alignment visible in a compact movement sequence. Three forms of scaffolding are examined: physical scaffolds, such as floor markers; verbal scaffolds, such as metaphorical prompts; and social scaffolds, such as peer synchronization. The study also examines how these supports are gradually withdrawn and how Leo responds during this fading process.

The study is guided by the following research questions:

RQ1: How does embodied scaffolding support spatial regulation in preschool ballet learning?

RQ2: How do physical, verbal, and social scaffolds influence movement coordination and attentional continuity?

RQ3: How does scaffold fading contribute to movement internalization?

By addressing these questions, the study aims to offer a process-oriented analytic framework for examining how young children develop movement regulation through embodied interaction, structured support, and gradual scaffold withdrawal.

2 Literature Review

2.1 ZPD and Dynamic Scaffolding

The theoretical basis of this study begins with Vygotsky's concept of the Zone of Proximal Development (ZPD), which explains learning as a mediated process between independent performance and assisted performance (Vygotsky, 1978). For preschool learners, this distinction is especially important because emerging competence is often visible before it can be verbally explained. In movement learning, a child may not be able to describe direction, rhythm, or balance, yet bodily performance may show partial regulation under teacher support.

Wood et al. (1976) developed this idea through the concept of scaffolding. In their study of children's problem solving, scaffolding referred to the tutor's temporary control of task elements that exceeded the learner's independent capacity. They identified key scaffolding functions, including recruitment, reduction of degrees of freedom, direction maintenance, marking critical features, frustration control, and demonstration. These functions are relevant to preschool ballet because teachers often support movement not only through verbal instruction but also through spatial markers, physical guidance, gesture, rhythm, and demonstration. In this sense, scaffolding enables children to complete tasks that would be beyond their unassisted efforts, while gradually allowing them to manage more of the task themselves.

Later research further emphasized that scaffolding is not a fixed instructional technique but a contingent and fading process. Van de Pol et al. (2010) identify contingency, fading, and transfer of responsibility as central features of scaffolding. This is directly relevant to the present study because the focus is not simply whether teacher support improves ballet performance, but how external supports are gradually withdrawn and replaced by the child's own bodily regulation.

In this study, therefore, scaffolding is treated as an observable process of movement regulation rather than as general instructional support. The key analytic concern is how physical, verbal, and peer-based scaffolds help the child stabilize direction, rhythm, and coordination, and how these supports fade over time.

2.2 Embodied Cognition and Movement Learning

Embodied cognition provides the second foundation for the study. Rather than treating cognition as separate from bodily action, embodied cognition argues that thinking is grounded in perception, movement, and interaction with the environment. Wilson (2002) summarizes this position by arguing that cognition is situated, action-oriented, and deeply connected to sensorimotor systems. Shapiro (2019) similarly emphasizes that cognition should be understood through the body's relation to the surrounding world.

This perspective is important for preschool ballet learning because movement difficulties are not merely technical errors. A child's unstable direction, delayed rhythm, or fragmented coordination may reflect the developing relationship between bodily attention, spatial perception, and motor planning. Recent embodied learning research also supports this view. Macedonia (2019) argues that learning is strengthened when bodily action participates in memory and understanding. Abrahamson et al. (2020) further show that embodied learning environments can support conceptual development by coordinating bodily action, spatial interaction, and guided mediation. Although their work focuses on mathematics education, the underlying principle is relevant to dance: learning can emerge through structured bodily engagement with space and feedback.

Recent reviews also show that embodied learning is increasingly understood as a multimodal process involving action, gesture, perception, and social interaction. Jusslin et al. (2022), for example, found that embodied learning approaches often combine bodily participation with social and affective engagement in educational settings. Similarly, Castro-Alonso et al. (2024) argue that embodied cognition can support learning through physical activity, generative action, observation of movement, and social cognition.

For the present study, embodied cognition justifies analyzing ballet learning as sensorimotor regulation rather than as the reproduction of dance forms. The child's body is not only executing instruction; it is perceiving, adjusting, remembering, and reorganizing movement. This is why the present study treats scaffolding as observable movement regulation rather than as general instructional support.

2.3 Preschool Ballet Learning and Spatial Instability

Preschool ballet provides a structured but developmentally demanding movement context. Unlike free movement play, ballet requires children to coordinate direction, posture, rhythm, pathway, and body alignment within a relatively fixed spatial order. However, preschool children are still developing attentional control, balance, bilateral coordination, and spatial orientation. As a result, early ballet learning often appears unstable.

Motor development research supports this interpretation. Adolph and Hoch (2019) argue that motor development is embodied, embedded, enculturated, and enabling, meaning that motor skills emerge through the interaction of the child's body, environment, cultural practice, and opportunities for action. This view is useful for preschool ballet because movement performance is shaped not only by instruction but also by classroom space, teacher guidance, peer movement, rhythm, and the child's developing sensorimotor capacity.

In the present study, spatial instability is not treated as a general teaching problem but as an analytic object. Three observable forms are especially important. First, directional instability refers to difficulty maintaining facing direction, pathway, or left-right orientation. Second, fragmented attention refers to moments when the child attends to one movement component while losing control of another, such as focusing on foot placement while losing rhythm or arm coordination. Third, rhythm discontinuity refers to delayed, interrupted, or uneven timing during movement sequences and transitions.

These three dimensions form the empirical bridge between the literature review and the coding framework. They are not merely descriptions of preschool ballet difficulty; they become the core movement-regulation indicators examined through video analysis. The purpose of the study is therefore not to evaluate ballet technique in an aesthetic sense, but to trace how direction, attention, rhythm, and coordination become more stable as scaffolds are introduced and faded.

Dance education research has shown that children’s dance learning involves effort, engagement, bodily meaning, and whole-child development (Anttila, 2013; Bond & Stinson, 2007). However, fewer studies have examined how specific movement-regulation problems unfold moment by moment in structured preschool ballet learning. This study addresses that limitation by treating spatial instability, fragmented attention, and rhythm discontinuity as observable coding targets within a video-based analytic framework.

2.4 Multimodal Analysis and Video-Based Learning Research

The methodological positioning of this study is grounded in multimodal and video-based learning research. Learning in preschool ballet is not expressed through speech alone. It appears through gesture, gaze, posture, spatial orientation, rhythm, peer synchronization, teacher demonstration, and the child’s bodily adjustments. For this reason, a language-centered analysis would be insufficient.

Multimodal research provides a way to examine how different semiotic and embodied resources work together in learning. Jewitt et al. (2016) argue that communication and learning are produced through multiple modes, including speech, gesture, image, body position, and spatial arrangement. In preschool ballet, these modes are inseparable. A teacher’s metaphor, a floor marker, a hand gesture, and a peer’s movement may jointly shape how a child regulates direction and timing.

Video-based learning research is particularly important because it allows repeated, fine-grained analysis of classroom interaction. Derry et al. (2010) argue that video research in the learning sciences requires systematic attention to selection, analysis, technology, and ethics. This is relevant to the present study because preschool ballet generates dense interactional data: teacher speech, bodily demonstration, music, spatial tools, peer movement, and child response occur simultaneously. Video makes it possible to slow down these events and examine how scaffolds are used, adjusted, and faded across time.

For the present study, video-based analysis is not merely a recording technique but the methodological basis for constructing observable movement codes. The video data allow the researcher to identify when a child depends on an external scaffold, when movement becomes more stable, and when regulatory responsibility begins to shift from teacher or peer support to the child’s own body. In this sense, video analysis directly supports the construction of codes for directional instability, fragmented attention, rhythm discontinuity, and scaffold fading.

Multimodal learning analytics further strengthens this methodological orientation. Blikstein and Worsley (2016) argue that multimodal learning analytics can capture complex learning processes in physical, collaborative, and open-ended environments. Although the present study does not use automated sensor-based analytics, it shares the same concern: learning processes involving body movement and interaction require data forms that can represent more than verbal output or test scores. Abrahamson et al. (2020) also note that embodied learning research increasingly relies on multimodal evidence, including movement, gesture, gaze, and verbal interaction.

Recent work by Walkington et al. (2024) is especially relevant because it examines multimodal analysis of interaction data from embodied educational technologies. Their study emphasizes that embodied learning can be investigated through coordinated analysis of movement, gesture, speech, and spatial positioning. Although the present study is situated in a low-technology ballet classroom rather than a technology-enhanced learning environment, the methodological logic is similar: embodied learning must be analyzed through visible, temporal, and multimodal traces of interaction.

The methodological contribution of this study therefore lies not only in its dance education context but also in its use of video-based multimodal analysis to transform preschool ballet learning into observable movement-regulation data. This provides the basis for examining how embodied scaffolding operates and fades over time.

2.5 LMA-Informed Observation Framework

To describe movement systematically, this study draws on Laban Movement Analysis (LMA), but it does not employ formal Labanotation. This distinction is essential. Formal Labanotation is a specialized notation system for recording movement in symbolic detail. The present study does not attempt to produce a full choreographic score or claim technical Labanotation analysis. Instead, it uses LMA concepts as an analytic lens for observing preschool movement regulation.

LMA provides a vocabulary for describing movement through dimensions such as Body, Space, Effort, and Shape. Bartenieff and Lewis (1980) connect movement analysis with bodily organization, environmental adaptation, and functional movement. Newlove and Dalby (2004) present Laban's movement principles in a form useful for dance educators, especially in relation to direction, level, pathway, timing, and dynamic quality. These concepts are suitable for the present study because they allow movement to be described in terms of spatial and temporal regulation rather than only technical correctness.

The observation framework used in this study is therefore LMA-informed but study-specific. It focuses on four dimensions that are directly related to the research question: spatial orientation, directional stability, rhythmic continuity, and whole-body coordination. These categories were selected because they correspond to the main movement-regulation difficulties observed in preschool ballet learning.

The codes used in this study are not universal LMA symbols; they are study-specific analytic labels derived from LMA concepts. For example, codes such as directional instability, unstable spatial support, delayed rhythmic response, or discontinuous timing are not presented as formal Labanotation. They are analytic labels developed to capture observable changes in the child's movement regulation across video-recorded sessions.

This clarification is important because the purpose of the framework is not to classify ballet movement according to a universal notation system. Rather, the purpose is to trace how external scaffolds become internalized as bodily regulation. If a child initially maintains direction only with a floor marker but later maintains direction after the marker is removed, this can be interpreted as evidence of scaffold fading and emerging spatial regulation. If a child first relies on peer synchronization to maintain rhythm but later sustains timing independently, this indicates a transfer of regulatory responsibility.

Thus, the adapted LMA-informed framework serves as a bridge between movement description and learning analysis. It makes the child's movement development visible, codable, and interpretable within a video-based qualitative case study.

2.6 Research Gap

The reviewed literature establishes the theoretical and methodological basis for the present study. Scaffolding theory explains how adaptive support, fading, and transfer of responsibility support learning. Embodied cognition explains why movement learning should be understood as sensorimotor regulation rather than as the execution of external instruction. Preschool motor development research shows that spatial instability, fragmented attention, and rhythm discontinuity are developmentally meaningful movement-regulation phenomena. Multimodal and video-based learning research provides the methodological basis for observing these phenomena in interaction. LMA offers a movement-sensitive vocabulary for describing spatial, temporal, and bodily organization.

However, several gaps remain. First, most scaffolding research has focused on language, problem solving, literacy, or general classroom cognition, with less attention to scaffold fading in early childhood movement learning. Second, embodied learning research has expanded rapidly, but structured preschool ballet remains underexamined as a context for studying bodily regulation. Third, dance education research has often emphasized creativity, expression, or engagement, while fewer studies have examined the micro-processes of directional stability, rhythmic continuity, and attention regulation. Fourth, video-based and multimodal learning research has rarely been applied to preschool ballet learning as a basis for constructing movement-regulation codes.

Therefore, few studies have examined scaffold fading and embodied movement regulation through video-based analytic frameworks in preschool ballet learning contexts. Addressing this gap, the present study develops an adapted LMA-informed and video-based qualitative framework to analyze how physical scaffolding, metaphorical verbal mediation, and peer synchronization support the child’s transition from external dependence to internalized bodily regulation.

3 Methodology

3.1 Research Design

This study adopted a qualitative microgenetic single-case design to examine how embodied scaffolding supported movement regulation in preschool ballet learning. A single-case design was selected not for statistical generalization, but for close process analysis of how movement regulation changed over time within a real instructional context (Yin, 2018). The microgenetic orientation was appropriate because the study focused on gradual changes in spatial regulation, attentional continuity, and scaffold dependence across an eight-week intervention.

The central aim was not to evaluate ballet technique as a final product, but to trace how a young learner’s movement organization developed through scaffolded interaction. For this reason, classroom video was treated as the primary analytic record. Video allowed repeated observation of movement episodes, including pathway deviation, gaze shifts, pauses, peer synchronization, and changes in reliance on physical, verbal, and social scaffolds.

3.2 Participant and Research Context

The participant, Leo, was a six-year-old preschool ballet learner who had received approximately 24 weeks of prior ballet training before the study began. Leo was selected as a typical case because he showed strong motivation and willingness to imitate, but continued to experience difficulty in spatial regulation, rhythm continuity, and movement coordination during structured locomotor tasks.

The study was conducted in a non-formal ballet classroom using a structured ballet curriculum. The intervention lasted eight weeks, with one 60-minute lesson recorded each week, producing approximately 480 minutes of classroom video. The focal task was diagonal walking, moving from corner 7 to corner 6 of the studio. This task was selected because it made several aspects of movement regulation visible within a compact sequence, including spatial pathway, body orientation, step length, rhythm, and attentional focus.

3.3 Data Collection

Data were collected through three sources: classroom video recordings, field notes, and interaction transcripts. Video recordings served as the primary data source. Each lesson was recorded using a fixed camera angle that captured Leo’s full-body movement pathway, the teacher’s scaffolding actions, peer movement, and the spatial arrangement of instructional tools.

Field notes were written after each lesson to document classroom context, Leo’s emotional responses, visible frustration, dependence on scaffolds, and teacher adjustments. Interaction transcripts were produced from selected episodes involving teacher–child dialogue, especially those containing metaphorical prompts or corrective feedback. These data sources were used together to support triangulation and to reduce reliance on a single observational perspective.

3.4 Video Segmentation Procedure

The video data were segmented into discrete movement episodes before coding. Each diagonal walking attempt was treated as one movement episode. An episode began when Leo prepared to initiate diagonal movement and ended when he reached the intended endpoint or stopped before completion.

Each episode was further divided into three temporal phases: movement initiation, mid-path regulation, and directional completion. Movement initiation referred to the moment of preparation, including gaze orientation, weight transfer, and first-step organization. Mid-path regulation referred to the central portion of the diagonal pathway, where pathway drift, rhythm interruption, or body-orientation changes were most visible. Directional completion referred to the final phase of the sequence, including deceleration, endpoint alignment, and completion stability.

This segmentation procedure allowed the analysis to identify not only whether Leo completed the task, but when instability appeared and how it changed across the intervention. It also made it possible to compare movement regulation under different scaffold conditions, including physical scaffolding, verbal scaffolding, peer synchronization, and scaffold fading.

3.5 Intervention Design: Embodied Scaffolding System

The intervention was organized around three forms of embodied scaffolding: physical scaffolding, verbal scaffolding, and social scaffolding.Physical scaffolding involved the use of floor markers and yoga blocks. Floor markers were placed along the diagonal pathway to provide visual anchors for step placement and direction. Yoga blocks were used as endpoint references to help Leo maintain spatial orientation.

Verbal scaffolding involved metaphorical prompts that translated abstract movement instructions into child-accessible imagery. For example, the metaphor of a “little train following the track” was used to help Leo understand diagonal pathway maintenance as a whole-movement intention rather than as separate foot placements.Social scaffolding involved peer synchronization through a “shadow imitation” task. Leo followed a more stable peer mover and used the peer's rhythm, pathway, and timing as a moving reference. This form of support was designed to provide both rhythmic guidance and social regulation.

Across the eight-week intervention, scaffolds were gradually reduced. Physical markers were first made less visually prominent and then removed. Verbal prompts were reduced from metaphorical cues to shorter reminders and later withdrawn. Peer support was also reduced, allowing Leo to complete the diagonal walking task independently.

Figure 1 summarizes the analytic logic of the intervention. It shows how physical, verbal, and social scaffolds were linked to specific regulatory functions and then translated into observable coding evidence through video-based analysis.

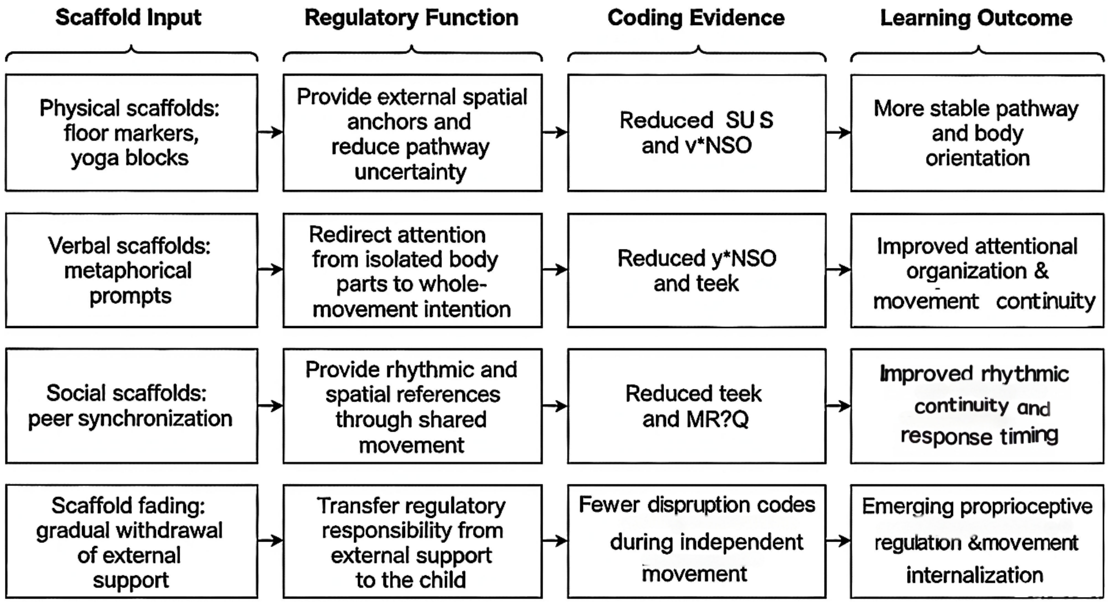

Figure 1: Video-Based Embodied Scaffolding Coding Framework

Note. The framework illustrates the analytic pathway from embodied scaffolding to video-based movement coding. Physical, verbal, and social scaffolds were linked to regulatory functions, which were then identified through observable movement indicators in the video data. Scaffold fading was analyzed as the gradual transfer of regulatory responsibility from external supports to the child's emerging proprioceptive regulation.

Because the research questions ask how embodied scaffolding supported movement regulation, the coding framework was not designed as a frequency-counting instrument alone. The codes were used to identify recurring disruptions in spatial support, directional orientation, movement flow, and movement response. However, the analytic focus was placed on the relationship between these disruptions and the scaffold conditions under which they appeared, decreased, or reappeared. For this reason, coding frequencies were treated as descriptive indicators rather than statistical outcomes. Each code was interpreted together with video evidence, teacher–child interaction, and scaffold fading records. This approach allowed the analysis to move beyond documenting that movement disruptions decreased, and instead explain how physical, verbal, and social scaffolds reorganized Leo's movement regulation over time.

3.6 Movement Coding Framework

The study used an adapted LMA-informed movement coding framework. The framework was informed by selected concepts from Laban Movement Analysis, particularly those related to space, time, and movement flow (Newlove & Dalby, 2004). However, the framework did not use formal Labanotation. The codes were study-specific analytic labels developed to capture observable movement-regulation patterns in preschool ballet learning.

Four coding categories were used:

SU:S referred to unstable spatial support. This code was assigned when Leo showed unstable weight transfer, poor pathway maintenance, or difficulty using the floor as a stable support during movement.

v*NSO referred to directional inconsistency. This code was assigned when Leo's head, torso, pelvis, or lower limbs showed inconsistent orientation in relation to the intended diagonal pathway.

teek referred to interrupted movement flow. This code was assigned when Leo's movement rhythm became uneven, hesitant, rushed, or discontinuous.

MR?Q referred to delayed movement response. This code was assigned when Leo showed delayed reaction to teacher prompts, peer movement, or rhythmic changes.

These codes were not intended to score ballet technique. Instead, they were used to trace changes in movement regulation, scaffold dependence, and internalization across the intervention.Based on this analytic logic, four movement-regulation codes were developed to capture Leo's observable difficulties and changes during diagonal walking tasks. Table 1 presents the operational definitions and video indicators for each code.

Table 1: Video-Based Movement Coding Framework for Preschool Ballet Learning

Code	Analytic Dimension	Operational Definition	Observable Indicators in Video Data	Related Scaffold Type
SU:S	Spatial support	Instability in foot placement, weight transfer, landing, or pathway maintenance during diagonal movement.	Unstable landing; visible weight shift; drifting away from the diagonal pathway; difficulty using the floor as a stable support.	Physical scaffolding
v*NSO	Directional orientation	Visual–bodily orientation mismatch between the child's gaze/target focus and the intended movement pathway.	Looking toward the endpoint while the torso, pelvis, or lower limbs remain misaligned; body alignment separates from the diagonal line; delayed directional correction after gaze shift.	Physical and verbal scaffolding
teek	Movement flow	Interruption, hesitation, or unevenness in rhythmic continuity during the movement sequence.	Sudden pause; rushed steps; uneven tempo; broken transition between steps; loss of movement continuity.	Verbal and social scaffolding
MR?Q	Movement response	Hesitant, delayed, or incomplete motor response after teacher prompts, peer movement, or rhythmic cues.	Late correction after teacher cue; delayed imitation of peer movement; waiting for confirmation; slow adjustment to rhythm or pathway change.	Social and verbal scaffolding

Note. The codes are study-specific analytic labels developed for video-based preschool movement observation. They are informed by selected Laban Movement Analysis concepts but should not be understood as formal Labanotation symbols. The framework is designed to capture observable movement-regulation patterns rather than to evaluate ideal ballet technique.

The coding frequencies in this study were not intended to function as statistical evidence of intervention effectiveness. Instead, they served as descriptive indicators for identifying changes in movement-regulation patterns across the intervention. Because the research questions ask how embodied scaffolding supported movement regulation, each coded occurrence was interpreted in relation to the scaffold condition, the child's visible movement response, teacher–child interaction, and the phase of scaffold fading. In this sense, frequency reduction alone was not treated as the answer to the research questions. Rather, the reduction of codes such as SU:S, v*NSO, teek, and MR?Q was used to locate moments where qualitative video analysis could explain how physical, verbal, or social scaffolds reorganized Leo's spatial orientation, attention, rhythm, and response timing.

3.7 Coding Procedure and Trustworthiness

Coding was conducted in three stages. First, all segmented episodes were reviewed in real time to identify general patterns of movement regulation and scaffold use. Second, selected episodes were reviewed using slow playback to examine pathway deviation, body orientation, rhythm, gaze, and timing of correction. Third, coded episodes were compared across early, middle, and late intervention phases to identify changes in scaffold dependence and movement regulation.

In total, ten focal lesson segments containing repeated diagonal walking attempts were selected from the eight-week video data. To support comparison across the intervention process, segments were drawn from the early scaffolding phase, the guided regulation phase, and the scaffold fading phase. Within these segments, each single diagonal walking attempt was assigned one primary code based on the most visible movement-regulation disruption. The same code was not counted repeatedly within the same attempt. This coding rule was used to avoid inflating frequencies and to ensure that the frequency table reflected observable episode-level movement patterns rather than repeated micro-errors within the same movement sequence.

To strengthen analytic trustworthiness, a second dance educator with experience in preschool ballet independently reviewed and coded approximately 25% of the selected video segments. The second coder was informed of the study purpose and the operational definitions of the four movement-regulation codes, but coded the selected segments independently before discussion with the researcher. The initial agreement rate between the researcher and the second coder was 95%. Disagreements mainly concerned borderline cases between delayed movement response and interrupted movement flow. These cases were discussed until interpretive consensus was reached. Cohen's kappa was not calculated because the study used qualitative process coding and did not aim to establish a large-scale quantitative reliability model. Instead, the agreement check was used to strengthen the transparency and consistency of the coding interpretation.

3.8 Ethical Considerations

Parental consent was obtained before video recording began. The child's name was replaced with the pseudonym "Leo." Video data were used only for research analysis and were stored securely. The study avoided using identifiable images in publication unless additional consent was obtained. The analysis focused on movement regulation and instructional process rather than personal evaluation of the child.

Table 2: Alignment Between Research Questions, Evidence Sources, and Analytic Focus

Research Question	Evidence Sources	Analytic Focus	How the Question Is Answered
RQ1: How does embodied scaffolding support spatial regulation?	Video episodes, SU:S, v*NSO, physical scaffold records	Pathway drift, landing stability, body orientation	By examining how visual anchors changed step preparation, pathway maintenance, and directional alignment.
RQ2: How do physical, verbal, and social scaffolds influence coordination and attentional continuity?	Video episodes, teek, MR?Q, transcript excerpts, peer tasks	Rhythm continuity, gaze direction, response timing	By analyzing how metaphor and peer synchronization redistributed attention and stabilized rhythm.
RQ3: How does scaffold fading contribute to movement internalization?	Scaffold fading records, Week 6–8 video episodes, reduced cue dependence	Reduced external support, self - correction, proprioceptive regulation	By tracing how Leo maintained movement organization when floor markers, prompts, and peer support were gradually reduced.

4 Findings

The frequency table should be read as a descriptive map of movement-regulation disruptions rather than as a statistical outcome table. The study does not claim that lower frequency alone explains learning. Instead, the frequency changes helped identify where Leo’s movement became more stable, and the subsequent qualitative analysis explains how specific scaffolds contributed to those changes. Therefore, each frequency pattern is interpreted together with video evidence, teacher–child interaction, and scaffold fading conditions.

This section presents the findings from the eight-week video-based observation of Leo’s diagonal walking tasks in preschool ballet learning. The analysis focuses on how embodied scaffolding supported movement regulation across four connected dimensions: physical scaffolding and spatial stabilization, verbal metaphor and attentional refocusing, peer synchronization and rhythmic continuity, and scaffold fading and movement internalization. Rather than treating improvement as a general classroom outcome, the findings trace how Leo’s movement organization changed through observable video evidence, including pathway stability, step preparation, body orientation, rhythm continuity, gaze direction, and reduced dependence on external supports.

The findings are organized around the three research questions. Sections 4.1 to 4.3 address how physical, verbal, and social scaffolds shaped spatial regulation, movement coordination, and attentional continuity. Section 4.4 focuses on scaffold fading and examines how Leo gradually shifted from externally guided movement to more independent proprioceptive regulation.

4.1 Physical Scaffolding and Spatial Stabilization

The first major finding was that physical scaffolding helped stabilize Leo’s spatial pathway during diagonal walking. In the early sessions, Leo’s movement showed frequent spatial instability. When asked to travel from corner 7 to corner 6, he often began with a roughly correct direction but gradually drifted toward the center of the room. This instability was not simply a matter of "walking in the wrong direction." Video analysis showed that the drift was closely related to unstable weight transfer, inconsistent foot placement, and delayed correction after the body had already moved away from the intended pathway.

In the coding framework, this pattern was mainly captured through SU:S, which referred to unstable spatial support. In Week 1, SU:S appeared frequently during the mid-path phase of diagonal walking. Leo's first two or three steps were usually more controlled, but once he entered the open central space of the studio, his pathway became less stable. Without a clear external reference, he appeared to rely on momentary visual checking rather than anticipatory control. His feet landed with uneven spacing, and his upper body often shifted slightly after each step, suggesting that the floor was not yet being used as a stable support for directional movement.

The introduction of floor markers and yoga blocks changed the structure of the task. The floor markers provided a visible pathway, while the yoga block at the endpoint gave Leo a concrete spatial target. This physical arrangement reduced the uncertainty of the diagonal pathway. Instead of asking Leo to imagine an abstract diagonal line, the teacher made the pathway visible and reachable. The markers did not complete the movement for him, but they reorganized the environment so that his body could begin to anticipate where the next step should land.

A clear change appeared in Leo's stepping pattern. In the early stage, he often corrected his pathway after drifting. After the introduction of floor markers, he began to prepare the next step before the foot landed. This shift can be described as anticipatory stepping. He looked ahead to the next marker, adjusted his stride length, and placed the foot with more control. The correction was no longer only reactive; it became partly anticipatory. This was important because it showed that the physical scaffold was not merely preventing error. It was helping Leo develop a more organized relationship between visual information, step preparation, and body alignment.

The reduction in SU:S across the intervention supports this interpretation. As shown in Table 3, the frequency of SU:S decreased from the early phase to the later phase. The decrease suggests that Leo's spatial support became more stable as the physical scaffold was introduced, used, and gradually reduced.

Table 3: Descriptive Frequency of Movement-Regulation Disruptions Across Intervention Phases

Code	Early Scaffolding Weeks 1–2	Guided Regulation Weeks 3–5	Scaffold Fading Weeks 6–8	Qualitative Interpretation
SU:S	10	6	3	Fewer unstable landings and less pathway drift after visual anchors were introduced and gradually reduced.
v*NSO	9	5	2	Greater alignment between gaze, torso, pelvis, and diagonal pathway.
teek	8	5	3	More continuous rhythm, especially during metaphor - guided and peer - supported movement.
MR?Q	7	4	2	Faster and more confident responses to teacher prompts, peer rhythm, and pathway cues.

Note.Frequencies refer to coded occurrences identified within ten selected focal lesson segments containing repeated diagonal walking attempts. The figures are descriptive indicators of movement-regulation disruptions across intervention phases, not statistical evidence of intervention effectiveness. Each single diagonal walking attempt was assigned one primary code based on the most visible disruption, and the same code was not counted repeatedly within the same attempt.

The reduction of v*NSO also indicated improvement in directional orientation. In the first session, Leo's head, torso, pelvis, and lower limbs did not always point toward the same spatial goal. A common pattern was that his head turned toward the endpoint while the pelvis and lower limbs remained slightly misaligned. This created a split between visual intention and bodily orientation. After several weeks of working with floor markers, this split became less frequent. Leo's body orientation began to follow the pathway more consistently, especially during the initiation and completion phases of the diagonal task.

The video data therefore suggest that physical scaffolding supported spatial stabilization in two ways. First, it provided external spatial anchors that reduced pathway uncertainty. Second, it supported the development of anticipatory stepping, allowing Leo to organize movement before visible error occurred. In this sense, the physical scaffold did not function as a passive teaching aid. It worked as an external regulatory structure through which Leo could begin to calibrate his own movement.

4.2 Verbal Metaphor and Attentional Refocusing

The second finding concerns the role of verbal metaphor in reorganizing Leo's attention. In the early sessions, Leo's attention was often fragmented. When the teacher reminded him to control the feet, he tended to look down and over-focus on foot placement. When reminded to face the endpoint, he lifted his head but lost control of step length. When asked to follow the rhythm, his pathway became unstable. This pattern suggested that Leo could attend to individual movement components, but he struggled to hold them together as one coordinated action.

The teacher's metaphorical prompt, especially the image of a "little train following the track," helped reduce this fragmentation. The metaphor translated an abstract ballet instruction into a familiar movement image. For a six-year-old learner, "maintain the diagonal pathway" is difficult because it requires spatial abstraction, body orientation, and movement planning at the same time. By contrast, "the little train stays on the track" gives the child a concrete image of direction, continuity, and purpose.

Video analysis showed that after the metaphor was introduced, Leo's gaze behavior changed. Instead of repeatedly looking down at his feet, he began to look forward along the pathway. This shift was important because it showed a redistribution of attention. His attention moved from isolated body parts to the whole movement pathway. The metaphor did not simply make the instruction more interesting; it reorganized the task in a form that Leo could act upon.

This finding can be understood as metaphorical mediation. The metaphor worked as a symbolic bridge between the teacher's instruction and the child's bodily action. It gave Leo a way to understand movement regulation without requiring him to process multiple technical corrections at once. When the teacher said that the "train" was moving away from the "track," Leo could quickly understand that his pathway had drifted. He did not need a long explanation about pelvis alignment, diagonal direction, or spatial angle. The metaphor compressed these ideas into one action image.

The effect of verbal metaphor was also visible in the reduction of v*NSO and teek. Directional inconsistency decreased because the metaphor helped Leo connect body orientation with pathway intention. Movement flow also improved because the metaphor encouraged continuity. A train does not stop after every step; it moves along a track. This image helped Leo avoid excessive stopping and restarting, which had been common in the early sessions.

The key point is that verbal scaffolding did not operate only at the level of language. It became a form of symbolic movement regulation. The words changed how Leo organized his body in space. They helped him hold the movement as a whole rather than as disconnected parts. This is especially important in preschool ballet learning, where too many technical corrections can overload the child's attention and weaken movement continuity.

However, the findings also suggest that verbal metaphor was most effective when it was connected to physical experience. The "track" metaphor worked because Leo could see and feel the floor markers. The language did not float above the movement; it was grounded in the spatial arrangement of the studio. This connection between metaphor and environment strengthened the scaffold. The physical markers made the metaphor visible, and the metaphor made the physical pathway meaningful.

By Week 4, Leo needed fewer long verbal explanations. Shorter prompts such as "find your track" or "stay on the line" were enough to trigger correction. This change suggests that the metaphor had begun to function internally. The teacher no longer needed to explain the full image each time. Leo could recall the movement meaning and apply it more quickly. This marked an early step toward internalized regulation.

4.3 Peer Synchronization and Rhythmic Continuity

The third finding was that peer synchronization supported Leo's rhythmic continuity and response timing. In the early sessions, Leo's movement rhythm was unstable. He sometimes rushed after realizing he had drifted from the pathway, and at other times paused abruptly when he became uncertain. These interruptions were coded as teek, referring to broken or uneven movement flow. The rhythm problem was not separate from spatial instability. When Leo lost the pathway, he often lost rhythm as well; when rhythm collapsed, his pathway became harder to maintain.

The "shadow imitation" task provided a different form of support. In this task, Leo followed a peer who demonstrated more stable diagonal walking. The peer did not verbally correct him. Instead, the peer provided a moving reference for timing, pathway, and body rhythm. This created a form of embodied synchronization, where Leo could regulate his own movement through another child's movement.

Video evidence showed that Leo's gaze during peer synchronization was more stable than during independent practice. He often looked toward the peer's lower body, especially the feet and ankles, and adjusted his own timing in relation to the peer's steps. This observation is important because it suggests that Leo was not merely copying the external shape of the movement. He was using the peer's movement as a rhythmic guide. The peer's stepping pattern gave him a temporal structure that helped reduce hesitation and rushing.

The reduction of teek from Week 1 to Week 8 supports this finding. In Week 1, movement flow was frequently interrupted by pauses, sudden accelerations, and uneven transitions. By Week 4, after repeated peer synchronization activities, Leo's rhythm became more continuous. By Week 8, teek occurred only occasionally in the selected episodes. This pattern suggests that social scaffolding contributed to the stabilization of movement flow.

Peer synchronization also influenced MR?Q, which referred to delayed movement response. In the early stage, Leo often responded slowly to teacher prompts or corrected his pathway only after the error had become obvious. During peer synchronization, his response time shortened. When the peer adjusted speed or direction, Leo followed more quickly. This faster response did not appear to come from verbal instruction alone. It emerged through shared movement.

This finding points to the role of social regulation in preschool dance learning. In a dance classroom, children do not learn only from the teacher. They also regulate themselves through the movement of others. A peer can provide rhythm, timing, emotional security, and a visible model of task completion. For Leo, the peer's body became a temporary regulatory reference.

This helped him maintain attention for longer periods and reduced the pressure of performing the task alone.

At the same time, the video data show that peer support needed careful control. When the peer moved too quickly, Leo's rhythm became rushed. When the peer's pathway was too far ahead, Leo lost the synchronizing reference. Therefore, peer scaffolding was most useful when the distance, speed, and task difficulty were adjusted to Leo's current level. This supports the view that social scaffolding is not simply "putting children together." It requires the teacher to structure the interaction so that the peer's movement remains available as a usable reference.

Overall, peer synchronization helped Leo move from isolated self-correction to shared rhythmic regulation. It reduced the burden of controlling space and rhythm alone. Through shared movement, Leo gradually learned to sustain rhythm, respond more quickly, and maintain attention across the diagonal task.

4.4 Scaffold Fading and Movement Internalization

The most important finding of the study concerns scaffold fading. The purpose of scaffolding is not to keep the learner dependent on support, but to transfer regulation from the external environment to the learner's own body. In this study, scaffold fading made it possible to observe whether Leo's improved movement regulation could remain stable when external supports were gradually withdrawn.

The fading process followed a clear sequence. Physical scaffolds were reduced first, followed by verbal prompts, and finally peer support. This order was not accidental. Physical markers were the most visible form of support and had the strongest immediate effect on pathway stabilization. Once Leo showed more stable stepping and fewer pathway deviations, the markers were made less salient and then removed. Verbal prompts were also shortened. Instead of detailed metaphorical reminders, the teacher used brief cues or delayed correction. Peer support was reduced later because it had helped Leo maintain rhythm and confidence during movement.

Table 4: Scaffold Fading Progression and Indicators of Movement Internalization

Phase	Scaffold Condition	Teacher Action	Leo's Movement Response	Internalization Indicator
Weeks 1–2	Full physical and verbal support	Floor markers, endpoint yoga block, and metaphorical prompts were provided throughout the task.	Leo frequently checked the floor markers and required repeated correction to maintain the diagonal pathway.	High dependence on external visual and verbal cues
Weeks 3–5	Stable physical support with reduced verbal prompting	Floor markers remained visible, but teacher prompts became shorter and less frequent.	Leo showed more stable step length and fewer abrupt pathway corrections.	Emerging self - monitoring of pathway and step placement
Weeks 6–7	Reduced physical support and delayed teacher correction	Some markers were removed or made less visually salient; teacher correction was delayed.	Leo maintained the diagonal pathway with occasional drift but corrected more independently.	Partial proprioceptive regulation
Week 8	Independent movement with minimal external support	Floor markers were removed, and teacher prompts were limited to task initiation.	Leo completed the diagonal pathway with more stable rhythm and fewer visible disruptions.	Increased autonomous movement regulation

The key change during scaffold fading was the shift from external regulation to internal regulation. In the early sessions, Leo's movement depended heavily on visible markers and teacher reminders. He looked for the floor markers before stepping, waited for correction when uncertain, and used the teacher's language as a guide. By the later sessions, he began to regulate the pathway with fewer external cues. He still showed occasional drift, but he corrected earlier and with less teacher intervention.

This shift was visible in three movement features. First, Leo's gaze became less dependent on floor markers. In the early stage, he frequently looked down to confirm foot placement. In the later stage, he looked more often toward the endpoint and used peripheral awareness to maintain direction. Second, his step length became more consistent. Even when markers were removed, he did not return to the large step-length variation seen in Week 1. Third, his rhythm remained more continuous during independent movement. The reduction of teek and MR?Q suggests that he was not only moving more accurately, but also responding more smoothly to the task demands.

The fading process also revealed that internalization was partial rather than complete. Leo did not become a fully independent mover in every situation. When the task became faster or when the classroom environment became distracting, small disruptions reappeared. This is important because it prevents overstatement of the findings. The study does not claim that eight weeks of scaffolding fully resolved all movement regulation difficulties. Rather, the evidence suggests that Leo developed a more stable regulatory system for this specific diagonal walking task.

The most meaningful indicator of internalization was not perfect performance, but reduced scaffold dependence. In Week 1, Leo needed external support to find the pathway, organize the step, and recover from error. By Week 8, he could initiate the diagonal task with minimal prompting, maintain a more stable pathway, and correct minor drift without immediate teacher intervention. This suggests that the regulatory function of the scaffold had begun to move into his own proprioceptive awareness.

Proprioceptive awareness was especially visible in the way Leo adjusted after small errors. In the early sessions, errors often led to visible hesitation or rushed correction. In the later sessions, he made smaller adjustments while continuing the movement. This showed that correction had become more integrated into the flow of action. He no longer needed to stop the movement completely in order to reorganize it. This is a central sign of movement internalization in a young learner: the child begins to regulate movement from within the action rather than after the action has broken down.

The findings therefore suggest that scaffold fading should not be understood as simple removal. It is a carefully timed transfer of responsibility. If support is removed too early, the child may lose confidence and return to unstable movement. If support remains too long, the child may complete the task successfully but fail to develop independent regulation. In Leo's case, fading was effective because it followed the visible changes in his movement coding. The reduction of SU:S and v*NSO indicated that physical support could be reduced. The reduction of teek and MR?Q indicated that rhythm and response timing were becoming more stable. In this way, the coding framework helped guide the interpretation of when and how support could be withdrawn.

Across the four findings, the study shows that embodied scaffolding supported Leo's movement regulation through a layered process. Physical scaffolds stabilized the spatial pathway. Verbal metaphor reorganized attention and movement intention. Peer synchronization supported rhythm and response timing. Scaffold fading then tested whether these gains could be maintained without continuous external support. Together, these findings show how preschool ballet learning can be analyzed not only as skill acquisition, but as a gradual process of embodied regulation and internalization.

5 Discussion

This study examined how embodied scaffolding supported a preschool ballet learner's movement regulation during diagonal walking tasks. The findings suggest that Leo's improvement was not simply the result of repeated practice or clearer instruction. Rather, movement regulation developed through a layered process in which physical, verbal, and social scaffolds temporarily reorganized the relationship among body, space, attention, and action. The discussion therefore focuses on the theoretical meaning of this process. It argues that scaffolding in preschool dance learning should be understood not only as instructional support, but as a form of embodied regulation mediation. It also considers how attention, scaffold fading, and video-based movement coding may contribute to future research in embodied learning analytics.

5.1 Embodied Scaffolding as Movement Regulation

One implication of this study is that scaffolding in movement learning should not be reduced to teacher instruction.In much educational research, scaffolding is often described as assistance provided by a more knowledgeable other to help the learner complete a task that would otherwise be beyond independent performance (Wood et al., 1976). This interpretation remains useful, but it is not sufficient for understanding preschool ballet learning. In a movement task such as diagonal walking, the learning difficulty is not only conceptual. The child does not merely need to "know" where to go. He must regulate weight transfer, direction, rhythm, gaze, and postural alignment while moving through space.

From this perspective, scaffolding operates as a temporary system of bodily regulation. The floor markers, yoga blocks, metaphorical prompts, and peer synchronization did not simply tell Leo what to do. They reorganized the conditions under which his body could act. Physical scaffolds reduced spatial uncertainty by making the diagonal pathway visible and reachable. Verbal metaphors condensed multiple technical demands into an action image. Peer synchronization provided a moving reference for rhythm and timing. In each case, the scaffold functioned as a mediator between the child's current regulatory capacity and the movement demands of the task.

This interpretation extends Vygotsky's (1978) notion of the Zone of Proximal Development into the bodily domain. The ZPD is often discussed in relation to language, problem solving, or cognitive development. In this study, however, the "zone" was visible in movement. Leo's independent level was marked by unstable spatial support, delayed correction, and fragmented attention. His potential level appeared when external supports allowed him to maintain the diagonal pathway, coordinate step length, and sustain rhythm more consistently. The gap between these two levels was not abstract. It was embodied in the difference between drifting and stabilizing, hesitating and continuing, reacting late and preparing early.

This also helps clarify why the study used a video-based movement coding framework. If scaffolding is treated only as verbal guidance, then ordinary classroom observation may be enough. But if scaffolding is understood as embodied regulation, the evidence must come from movement itself. Codes such as SU:S, v*NSO, teek, and MR?Q made it possible to observe how regulation appeared, failed, and changed across time. In this sense, the coding framework did not merely record improvement. It made visible the regulatory work that scaffolds performed in the child's movement.

The study therefore suggests a shift in how scaffolding is conceptualized in dance pedagogy. Scaffolding is not only a teaching strategy added to movement learning. It is part of the movement-learning environment itself. It shapes what the child can perceive, how the child can act, and when the child can begin to take over regulatory responsibility. This view is consistent with embodied cognition, which argues that cognition is grounded in bodily action and situated interaction rather than located solely in internal mental representation (Wilson, 2002). For preschool ballet learning, this means that teaching support must be designed not only for understanding, but also for bodily regulation.

5.2 Attention as an Embodied Process

A second theoretical contribution concerns attention. In early childhood dance classes, attention is often treated as a behavioral issue: the child is attentive or inattentive, focused or distracted. The present study suggests a more precise interpretation. Leo’s attentional difficulty was not simply a lack of concentration. It was closely tied to the organization of the movement task. When the task required him to control foot placement, direction, rhythm, and posture at the same time, his attention became fragmented. When the scaffold reorganized the task, attention became more stable.

This finding supports the view that attention is not only a mental resource but also an embodied process. In movement learning, attention is distributed across gaze, posture, spatial orientation, timing, and environmental reference points. Leo’s gaze shifts were especially important. When he over-focused on his feet, his pathway and torso alignment became unstable. When he looked only toward the endpoint, his step length sometimes became irregular. With physical markers and metaphorical prompts, his attention gradually shifted from isolated body parts to the whole movement pathway. This was not merely a change in where he looked; it was a change in how he organized action.

The metaphor of the “little train following the track” played a key role in this redistribution of attention. It helped Leo understand the diagonal pathway as a continuous movement intention rather than a sequence of separate corrections. This aligns with Vygotsky’s (1978) account of symbolic mediation, in which signs and language support the organization of action. However, in this study, the metaphor did not work as language alone. It was effective because it was grounded in visible markers and bodily movement. The “track” could be seen, stepped on, and felt through movement. The metaphor therefore became an embodied sign.

This point is important for preschool dance pedagogy. Young children often struggle when teachers provide too many technical corrections at once. A correction such as “keep your body facing the diagonal, control your feet, and follow the rhythm” may be accurate, but it can exceed the child’s attentional capacity. A well-chosen metaphor can reduce this burden by organizing several movement demands into one meaningful image. The value of metaphor is not that it makes teaching more playful, although it may do that. Its deeper value is that it can reorganize attention into an actionable form.

The findings also suggest that attentional continuity depends on rhythm and social context. During peer synchronization, Leo’s attention was sustained not through verbal reminders but through shared movement. The peer’s body provided a temporal structure that helped Leo maintain rhythm and respond more quickly. This indicates that attention in dance learning is socially and rhythmically supported. It is not located only inside the individual child. It emerges through the child’s coupling with the environment, the teacher’s cues, and the movement of others.

For this reason, attention should be treated as part of embodied movement regulation. In preschool ballet learning, the teacher’s task is not only to ask the child to “focus.” The more important task is to design conditions under which focus becomes possible. Physical anchors, metaphors, and peer rhythm all helped Leo sustain attention because they gave his body something stable to organize around.

5.3 Scaffold Fading and Proprioceptive Internalization

A key theoretical contribution of the study concerns scaffold fading.In scaffolding theory, support is expected to be gradually withdrawn as the learner gains control (Wood et al., 1976). Yet in movement-based learning, the mechanism of fading is often underexplored. The present study shows that fading is not simply the removal of support. It is a transfer of regulatory responsibility from the external environment to the learner’s own proprioceptive system.

In the early phase, Leo’s movement regulation depended heavily on external references. He used floor markers to locate the pathway, teacher prompts to recover direction, and peer movement to sustain rhythm. These supports were necessary because his internal regulation was not yet stable enough to manage the task independently. As the intervention progressed, the supports were reduced. The critical question was whether Leo could maintain movement organization when the external system was no longer fully available.

The findings suggest that internalization became visible through reduced scaffold dependence. Leo did not simply perform the task more successfully when support was present. More importantly, he maintained a more stable pathway and rhythm when support was reduced. This shift indicates emerging proprioceptive internalization. Proprioception refers to the body’s sense of position, movement, and effort. In this study, proprioceptive internalization was observed when Leo began to correct small pathway deviations without stopping, maintain more consistent step length without visible markers, and sustain rhythm without continuous peer support.

This process can be understood as a movement-based form of internalization. Vygotsky’s (1978) theory emphasizes the transformation of socially mediated activity into internal psychological function. In Leo’s case, the transformation was not primarily verbal. It was bodily. External markers, teacher language, and peer rhythm gradually became part of how Leo organized his own movement. The regulatory function first carried by the environment was partly taken over by the child’s body.

This interpretation also explains why fading must be carefully timed. If physical markers are removed before the child has developed sufficient anticipatory stepping, pathway instability may return. If verbal prompts remain too long, the child may wait for correction rather than self-monitor. If peer support is withdrawn too quickly, rhythm and confidence may collapse. Effective fading therefore requires close observation of movement evidence. The reduction of disruption codes such as SU:S, v*NSO, teek, and MR?Q provided signs that Leo was becoming more ready for reduced support.

The study does not claim that internalization was complete. This distinction is important. Leo’s movement remained vulnerable to task difficulty, speed, and environmental distraction. However, the findings show a meaningful shift from externally guided regulation toward partial autonomous control. For preschool learners, this partial shift is educationally significant. It indicates that the child has begun to regulate movement from within the action, rather than only after receiving external correction.

This has broader implications for dance teaching. Teachers often remove support based on time, curriculum pace, or the assumption that a child “should be ready.” The present study suggests that fading should instead be guided by movement evidence. When the child can anticipate the next step, recover from minor drift, and maintain rhythm with less prompting, support can be reduced. In this sense, scaffold fading is not a fixed teaching stage. It is an evidence-informed pedagogical decision.

5.4 Implications for Embodied Learning Analytics

The study also contributes to embodied learning analytics by showing how video-based coding can be used in a low-technology classroom setting. Recent work in multimodal learning analytics has emphasized the value of tracking learners' gestures, body movements, spatial positions, interactions, and talk across time and space (Walkington et al., 2024). Much of this work is connected to digital learning environments, augmented reality, motion capture, or sensor-based systems. The present study does not use such technologies. Its contribution lies in showing that embodied educational observation can still be made more systematic through carefully designed video segmentation and movement coding.

This is important for dance education because many studios and early childhood classrooms do not have access to motion capture systems or wearable sensors. If embodied learning analytics is to be useful beyond laboratory settings, it needs methods that can work with ordinary classroom video. The adapted LMA-informed coding framework offers one possible approach. It does not replace formal Labanotation, nor does it claim the precision of biomechanical measurement. Instead, it provides a practical middle level between general teacher observation and highly technical movement analysis.

The value of this approach lies in its ability to connect teaching support with observable movement change. Physical scaffolding could be linked to reductions in SU:S and v*NSO. Verbal metaphor could be linked to changes in gaze, pathway intention, and movement flow. Peer synchronization could be linked to reductions in teek and MR?Q. Scaffold fading could be examined through the persistence or reappearance of disruption codes during independent movement. This creates an evidence chain from scaffold design to movement regulation.

For EI-oriented research, this methodological contribution is especially relevant. The study does not simply describe a teaching case; it proposes a structured analytic framework. The framework combines multimodal observation, video segmentation, movement coding, and process-level interpretation. This aligns with the broader direction of multimodal learning analytics, which seeks to understand learning through multiple forms of behavioral and interactional evidence rather than through test scores alone (Blikstein & Worsley, 2016; Walkington et al., 2024).

At the same time, the study argues for caution. More data does not automatically produce better interpretation. Movement analytics must remain theoretically grounded. Without a theory of embodied regulation, codes can become mechanical labels. Without classroom context, frequency counts can be misleading. The strength of the present framework is that the codes are tied to specific pedagogical questions: how spatial support stabilizes movement, how metaphor reorganizes attention, how peer rhythm supports continuity, and how fading reveals internalization.

Future research could build on this framework by combining video coding with additional data sources, such as motion tracking, wearable sensors, or eye-tracking. However, the present study shows that even without advanced technology, a carefully structured video-based approach can make preschool movement learning more visible, analyzable, and discussable. This is a practical contribution for dance teachers and a methodological contribution for embodied learning research.

5.5 Limitations

Several limitations must be acknowledged. First, this study is based on a single case. Leo was selected because his learning profile made movement regulation visible, but the findings cannot be generalized statistically to all preschool ballet learners. The study offers analytic generalization rather than population-level generalization. Its value lies in the depth of process analysis rather than sample size.

Second, the study used a qualitative microgenetic design. This design was appropriate for tracing movement change across time, but it does not allow causal claims in the experimental sense. The observed changes were associated with the scaffolded intervention, but other factors may also have contributed, including repeated practice, growing familiarity with the task, teacher–child rapport, and classroom routine.

Third, the study did not use motion capture, wearable sensors, force plates, or automated pose-estimation tools. As a result, the analysis depended on video-based human coding. Although the coding procedure was designed to improve trustworthiness, it cannot provide the same biomechanical precision as sensor-based analysis. Pathway deviation, rhythm interruption, and response timing were interpreted through observable video evidence rather than instrument-based measurement.

Fourth, the coding framework was adapted for the specific context of preschool ballet diagonal walking. Codes such as SU:S, v*NSO, teek, and MR?Q were useful for this case, but they require further testing in other movement tasks, age groups, and dance forms. Future studies should examine whether the framework can be applied to group learning, creative dance, folk dance, or other structured locomotor tasks.

Finally, the dual role of the researcher as teacher and observer may have influenced interpretation. Reflexive notes and video review helped reduce this risk, but it cannot be fully removed. Future research could include independent coders, inter-rater reliability statistics, and mixed-method designs to strengthen analytic credibility.

Despite these limitations, the study provides a useful starting point for understanding embodied scaffolding in preschool ballet learning. It shows that movement regulation can be studied through a structured video-based framework, and that scaffold fading can be analyzed as a process of proprioceptive internalization rather than as a simple reduction of teacher support.

6 Conclusion

6.1 Summary of Findings

This study examined how embodied scaffolding supported movement regulation in preschool ballet learning through an eight-week video-based single-case study of Leo, a six-year-old ballet learner. The study focused on diagonal walking as a structured movement task because it made spatial regulation, body orientation, rhythm continuity, attentional focus, and scaffold dependence clearly observable within a repeated classroom activity.

The findings suggest that Leo’s movement development was not simply a result of repeated practice.Rather, his progress emerged through the interaction of physical, verbal, and social scaffolds. Physical scaffolds, including floor markers and yoga blocks, helped stabilize the diagonal pathway by providing external spatial anchors. These supports reduced pathway uncertainty and encouraged anticipatory stepping. Verbal scaffolds, especially metaphorical prompts such as the image of a “little train following the track,” helped redirect Leo’s attention from isolated body parts to the whole movement pathway. Social scaffolds, particularly peer synchronization, supported rhythmic continuity and faster response to movement cues.

The most important finding concerns scaffold fading. As external supports were gradually withdrawn, Leo began to show reduced scaffold dependence and more stable self-regulation. Although his internalization was not complete, the video evidence suggested a meaningful shift from externally guided movement toward emerging proprioceptive regulation. This shift was visible in more consistent step length, fewer pathway disruptions, improved rhythm continuity, and earlier self-correction during independent movement.

6.2 Theoretical Contributions

One theoretical contribution of this study is the reconceptualization of scaffolding as embodied movement regulation. In preschool ballet learning, scaffolding is not only a form of verbal instruction or task assistance. It functions as a temporary regulatory system that helps the child organize body, space, rhythm, and attention. The study therefore extends scaffolding theory from a primarily cognitive or linguistic model toward a bodily and spatial model of learning.

Second, the study contributes to understanding scaffold fading in movement-based education. Scaffold fading is often described as the gradual withdrawal of support, but this study shows that fading is more than removal. It is a transfer of regulatory responsibility from the environment, teacher, and peer to the learner’s own body. In Leo’s case, this transfer was observed through reduced dependence on floor markers, shorter teacher prompts, and less reliance on peer movement.

Third, the study develops the concept of movement internalization as a proprioceptive process. Internalization in this context does not mean that the child can verbally explain the movement. It means that the child begins to regulate movement from within the action itself. When Leo could maintain direction, adjust step length, and correct minor drift without stopping or waiting for teacher correction, movement regulation had begun to shift into bodily awareness. This finding highlights the importance of proprioception in early childhood dance learning and suggests that movement internalization should be studied as an embodied developmental process.

6.3 Methodological Contributions

Methodologically, this study offers a video-based movement coding framework for analyzing embodied scaffolding in preschool ballet learning. Instead of relying only on general classroom description or teacher reflection, the study used video segmentation and adapted movement codes to trace changes in spatial support, directional orientation, movement flow, and response timing.

The framework is LMA-informed but does not use formal Labanotation. This distinction is important. Formal movement notation may be too complex for everyday preschool classroom analysis, while ordinary teaching observation may lack sufficient movement specificity. The adapted coding framework offers a practical middle level: it is structured enough to support systematic analysis, but flexible enough to capture the variable and emergent nature of young children’s movement.

This methodological contribution is especially relevant for embodied learning analytics. The study demonstrates that movement learning can be analyzed through ordinary classroom video when supported by clear segmentation procedures, operationalized codes, and process-level interpretation. The coding framework also helps connect teaching strategies with observable movement evidence. Physical scaffolding, verbal metaphor, peer synchronization, and scaffold fading can be examined not only as pedagogical ideas, but as processes that leave visible traces in movement organization.

6.4 Future Directions

Future research can extend this study in several directions. First, the video-based coding framework should be tested with more participants, different age groups, and different dance forms. A larger sample would help examine whether the patterns identified in Leo's case also appear in other preschool learners.

Second, future studies could combine human video coding with AI-assisted movement analysis. Computer vision tools may help detect pathway deviation, body orientation, step timing, and rhythm changes with greater precision. However, AI analysis should not replace pedagogical interpretation. It should be used to support, not substitute, teacher-informed movement analysis.

Third, motion tracking and wearable sensors could be introduced to strengthen the measurement of spatial trajectory, timing, balance, and movement variability. Such tools may provide more precise data on how external scaffolds influence bodily regulation over time.

Fourth, future research should develop multimodal embodied analytics that integrate video, teacher talk, peer interaction, gaze direction, spatial movement, and possibly physiological indicators. This would allow researchers to examine preschool movement learning as a complex system involving body, environment, language, rhythm, and social interaction.

Finally, this line of research may support the design of preschool movement learning systems. Such systems could help teachers identify when children need physical, verbal, or social scaffolds, and when those supports should be faded. In this way, embodied scaffolding can move from a teaching intuition toward a more observable, evidence-informed practice in early childhood dance education.

Appendix

Appendix A: Examples of Movement Coding from Selected Diagonal Walking Episodes

Episode	Week	Movement Segment	Code	Video - Based Indicator	Analytic Interpretation
E1	Week 1	Mid-path regulation	SU:S	Leo's landing point shifted away from the diagonal line, with visible weight instability after foot contact.	Indicates unstable spatial support and limited use of the floor as a stable base for directional movement.
E2	Week 1	Directional completion	v*NSO	Leo's head turned toward the endpoint, while the pelvis and lower limbs remained slightly misaligned.	Shows inconsistency between visual intention and body orientation.
E3	Week 2	Mid-path regulation	teek	Leo paused briefly after the third step and then rushed the following two steps.	Indicates interrupted movement flow and unstable rhythm continuity.
E4	Week 3	Peer synchronization	MR?Q	Leo adjusted his step timing after observing the peer's movement, but the response was delayed.	Suggests partial use of peer movement as a social - rhythmic reference.
E5	Week 5	Guided regulation	v*NSO	After a brief verbal cue, Leo corrected body orientation before the pathway drift became obvious.	Indicates improved anticipatory regulation of direction.
E6	Week 8	Independent movement	Reduced disruption	Leo completed the diagonal pathway with stable step length and no visible pause.	Suggests reduced scaffold dependence and emerging proprioceptive regulation.

Note. The examples are selected from repeated diagonal walking episodes. The codes are used to identify observable movement-regulation patterns rather than to evaluate ballet technique.

Appendix B: Example of Video Segmentation Procedure

Segment Phase	Time Marker	Description of Movement Event	Main Observation Focus	Potential Coding Focus
Movement initiation	00:00–00:04	Leo prepares to begin diagonal walking, shifts weight, and looks toward the endpoint.	Gaze direction, first-step preparation, initial body orientation.	v*NSO, MR?Q
Early pathway	00:05–00:09	Leo takes the first two to three steps along the diagonal pathway.	Step length, landing stability, early pathway control.	SU:S, teek
Mid-path regulation	00:10–00:16	Leo enters the center area of the studio, where spatial drift is most visible.	Pathway deviation, body alignment, rhythm continuity, self-correction.	SU:S, v*NSO, teek
Directional completion	00:17–00:22	Leo approaches the endpoint and slows down.	Endpoint alignment, deceleration, final body orientation.	v*NSO, MR?Q
Post-movement response	00:23–00:28	Teacher gives feedback or Leo responds to the completed movement.	Verbal response, emotional reaction, readiness for next attempt.	MR?Q

Note. Each diagonal walking attempt was treated as one movement episode. The episode was segmented to identify when movement instability occurred and how Leo responded to scaffolding within the task.

Appendix C: Selected Teacher–Child Interaction Excerpts

The excerpts are translated and lightly edited for clarity. Names are pseudonyms.

Excerpt 1. Verbal Metaphor and Attentional Refocusing

Context: Week 2, diagonal walking with floor markers.

Teacher: Leo, your little train is moving away from the track. Where is your track?

Leo: Here. The dots are the track.

Teacher: Good. Let your feet follow the track, and let your body face the station.

Leo: I need to go to that block.

Teacher: Yes. Keep the train moving to the station.

Analytic note:

This excerpt shows how metaphorical language redirected Leo’s attention from isolated foot placement to the whole movement pathway. The “train” and “track” image functioned as a symbolic scaffold that connected direction, rhythm, and endpoint awareness.

Excerpt 2. Physical Scaffold and Anticipatory Stepping

Context: Week 3, diagonal walking with floor markers and endpoint yoga block.

Teacher: Before you step, look at the next marker.

Leo: This one?

Teacher: Yes. See it first, then step.

Leo: I can step on it.

Teacher: Try to prepare before your foot lands.

Analytic note:

This excerpt illustrates the transition from reactive correction to anticipatory stepping. The teacher’s prompt encouraged Leo to organize the next step before landing, supporting more stable spatial regulation.

Excerpt 3. Peer Synchronization and Rhythmic Continuity

Context: Week 4, shadow imitation task with peer model.

Teacher: Leo, follow her steps like a shadow. Do not rush.

Leo: I follow her feet?

Teacher: Yes. Watch the rhythm, not only the feet.

Peer: I go slowly.

Leo: I can go with you.

Analytic note:

This excerpt shows how peer movement provided a social-rhythmic scaffold. Leo used the peer's movement as a timing reference, which helped reduce hesitation and improve movement continuity.

Excerpt 4. Scaffold Fading and Independent Regulation

Context: Week 8, diagonal walking without floor markers.

Teacher: This time, no dots. Find the pathway by yourself.

Leo: I remember the track.

Teacher: Good. Start when you are ready.

Leo: I go to the block line.

Teacher: Yes. Keep your body moving with the pathway.

Analytic note:

This excerpt indicates reduced scaffold dependence. Although the physical markers were removed, Leo referred to the remembered pathway and initiated the task with minimal prompting, suggesting emerging proprioceptive internalization.

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