TEACHERS' ORCHESTRATION OF MULTIMODAL MEANING-MAKING APPROACHES IN PRIMARY MATHEMATICS

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This study examines how Finnish primary school teachers orchestrate Embodied Language (EL) alongside natural, pictorial, and mathematical symbolic language in mathematics classrooms. EL is conceptualized as analytically distinct domains of bodily, tactile, spatial, rhythmic, and playful participation in mathematical meaning-making. The study re-analysed classroom observation data from a qualitative multi-case study involving five lessons taught by three teachers. Qualitative episode analysis shows that EL functioned in qualitatively different ways—as a bridge to abstraction, as structured sense-making, and as procedural support—highlighting the pedagogical importance of intentional coordination of embodied action within instruction. Practical challenges and affordances in multimodal teaching are also addressed.

INTRODUCTION

Supporting students' sense-making in mathematics is a central concern in mathematics education research, particularly in primary classrooms where learners encounter formal mathematical concepts for the first time. Prior research emphasizes that mathematical understanding does not emerge from symbolic representation alone but through coordinated activity involving language, perception, action, and social interaction, including embodied learning (Frey et al., 2024; Krause & Shvarts, 2022; Palatnik et al., 2023; Way & Ginns, 2024). From this perspective, embodiment is not only a cognitive resource but also a social and effective dimension of mathematical meaning-making (Hannula, 2012). Here, embodied approaches foreground concrete experience and action (Joutsenlahti & Perkkilä, 2022), involving manipulatives, digital tools, and movement- or play-based routines (Krause & Shvarts, 2022; Palatnik et al., 2023).

However, the presence of embodied activities alone does not guarantee conceptual understanding. Without deliberate pedagogical integration, embodied experiences may remain disconnected from formal representations or function merely as playful activity (Abrahamson et al., 2020; Way & Ginns, 2024). This underscores the importance of examining how embodied activities are orchestrated as part of teachers' intentional instructional design rather than treated as isolated or supplementary practices. A further challenge concerns the conceptual status of embodied activity in instruction. Bodily actions such as clapping, stepping, gesturing, or game-based movement are common in primary mathematics lessons, yet they are often interpreted as motivational or preparatory rather than epistemically meaningful (DePascale & Ramani, 2025). Such positioning risks overlooking how embodied participation can shape learners'

2026. In H. Krzywacki, M. Hähkiöniemi, E. Haataja, M.S. Hannula & P. Hästö (Eds.). *Proceedings of the 49th Conference of the International Group for the Psychology of Mathematics Education: Research Reports*, pp. 811-818. PME.

engagement, affective orientation, and access to mathematical meaning (Hannula, 2012). At the same time, defining embodiment too broadly risks analytical diffusion, whereas overly narrow definitions may exclude routine but pedagogically relevant practices. This tension highlights the need for a more fine-grained conceptualization of embodied participation in mathematics classrooms (Way & Ginns, 2024).

To address these challenges, this study draws on Languaging approaches developed in Finnish mathematics education and introduces an extended, analytically differentiated concept of Embodied Language (EL). Rather than treating EL as a single category, the study identifies distinct domains of embodied participation informed by prior research and examines how these domains are coordinated with other semiotic modes during mathematics instruction.

Research question

The study addresses the following research question: How do Finnish primary school teachers orchestrate domains of Embodied Language in coordination with natural, pictorial, and mathematical symbolic modes during mathematics teaching?

LANGUAGING APPROACHES IN FINNISH MATHEMATICS EDUCATION

Languaging approaches conceptualize mathematical learning as a process in which mathematical thinking is expressed through natural language, pictorial language, mathematical symbolic language, and body language (Joutsenlahti & Perkkilä, 2019, 2024). Body language refers to students' bodily and tactile expressions of mathematical thinking, particularly through action and material engagement. In the present study, this mode is reconceptualized as Embodied Language (EL) to foreground a broader range of bodily, spatial, rhythmic, and play-based enactments of mathematical meaning.

Figure 1: Example of Languaging approaches to understanding the concept of 2/3.

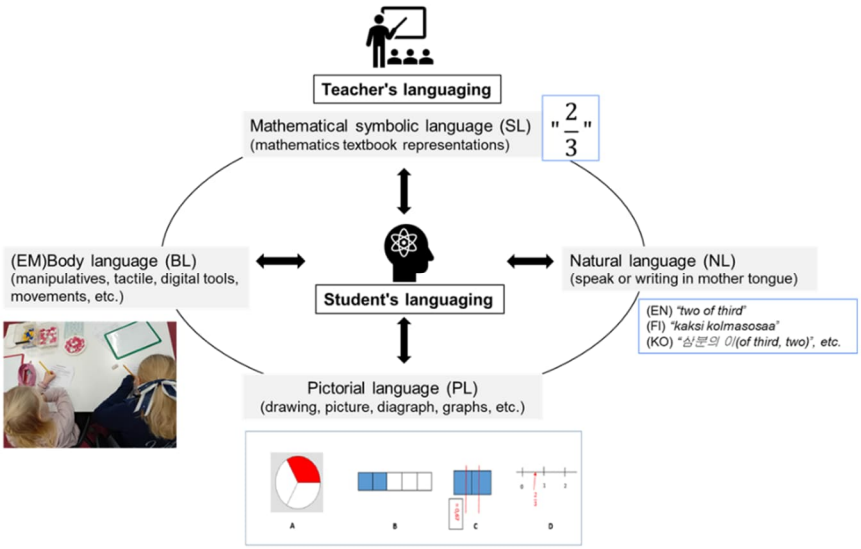


Figure 1 illustrates how teachers' planned Languaging approaches mediate students' understanding of the concept of 2/3. The four modes are interconnected and mutually

reinforcing, enabling students to explore multiple meanings of the same symbol—fraction, ratio, division, and rational number (A–D in Figure 1). Languaging approaches refer to the design of tasks and interactions that support flexible movement between modes, thereby fostering conceptual development and participation in mathematical discourse. Interaction with materials, hands-on activities, and play-based contexts can support understanding, particularly when learning is socially embedded (DePascale & Ramani, 2025; Hannula, 2012; Joutsenlahti & Perkkilä, 2022). Crucially, the pedagogical value of EL depends on how it is organized within instructional formats—individual, pair, group, or whole-class—to guide mathematical sense-making (Marco & Palatnik, 2025).

Domains of Embodied Language as an analytical construct

This study conceptualizes Embodied Language (EL) as a multi-domain semiotic resource for examining how bodily action and material engagement function pedagogically in mathematics instruction (Palatnik et al., 2023; Way & Ginns, 2024). Drawing on prior research, five recurring EL domains are analytically distinguished: tactile–manipulative structuring (EL1), spatial–embodied structuring (EL2), digitally mediated embodied action (EL3), rhythmic and gestural embodiment (EL4), and playful embodied engagement oriented toward mathematical goals (EL5). These domains function as analytical lenses rather than activity categories, enabling examination of how embodied participation is positioned and coordinated with natural (NL), pictorial (PL), and symbolic language (SL) within instructional sequences.

RESEARCH DESIGN

This study adopted a qualitative multi-case design (Cohen et al., 2002), examining five mathematics lessons taught by three Finnish primary school teachers (Grades 2 and 4). Each lesson was treated as an analytical unit within its classroom case, enabling within-case and cross-case analysis of pedagogical orchestration in authentic teaching contexts. Data were collected through classroom observations, including audio recordings, structured field notes, and photographs of learning materials and student activity. The observations were previously analyzed using a validated classroom observation protocol (Kim et al., 2025); the present study re-analyses this dataset with a specific focus on Embodied Language (EL) and its instructional coordination.

The analysis proceeded in three stages. First, lessons were segmented into instructional units by working format: whole-class (W), group (G), pair (P), and individual (I). Second, embodied participation was identified through classroom transcripts and observational records in which EL was salient. Third, coordination between EL and NL, PL, and SL was examined within and across instructional units. Qualitative episode analysis focused on representational transitions, activity sequencing, and the instructional positioning of embodied actions. Pedagogical intentionality was inferred from representational coordination and instructional organization rather than from the mere presence of bodily activity. Trustworthiness was supported through triangulation

of transcripts, field notes, and visual data, and through iterative discussion with mathematics education researchers to resolve interpretive discrepancies. The study adhered to Finnish national ethical guidelines. Participation was voluntary, informed consent was obtained from teachers and guardians, and all data were anonymized.

RESULTS

The participating teachers are referred to using pseudonyms (Teacher 1, Teacher 2, and Teacher 3). Individual observed lessons are labeled as Cases 1–5. Table 1 summarizes the instructional phases in which Embodied Language (EL) was salient across all five cases. Only phases involving embodied participation are reported, enabling comparison of how different EL domains were selectively coordinated with natural (NL), pictorial (PL), and symbolic language (SL) across working formats.

Table 1: Instructional phases with salient Embodied Language (EL).

Case	Teacher	Phase	Working format	EL domain with other modes
Case 1	Teacher 1	P2	Pair / Group	EL1 (tactile–manipulative), NL, SL
		P3	Group	EL5 (playful movement), NL
		P4	Whole-class	EL2 (spatial–embodied), NL, SL
		P5	Whole-class	EL1 , NL
Case 2	Teacher 1	P6	Pair	EL1, PL, SL
		P7	Whole-class	EL2, NL
Case 3	Teacher 2	P1	Whole-class	EL5, NL, PL, SL
		P2	Whole-class	EL4 (rhythmic/gestural), NL
		P3	Pair / Group	EL1, NL, SL
		P4	Individual / Whole	EL1, NL
		P5	Individual / Whole	EL1, NL, PL
Case 4	Teacher 2	P1	Individual	EL1, NL
		P2	Individual / Group	EL1, NL
		P3	Whole-class	EL5, PL
		P4	Individual / Whole	EL2, NL, PL, SL
Case 5	Teacher 3	P1	Whole-class	EL1, NL, PL, SL
		P2	Individual / Whole	EL1, NL, PL, SL

Overall, Table 1 reveals three salient patterns. First, tactile–manipulative structuring (EL1) was the most frequently used domain across cases and working formats and was consistently coordinated with NL and SL. Second, spatial–embodied structuring (EL2) and playful embodied engagement (EL5) occurred primarily in whole-class phases, often serving to connect individual or small-group work to collective sense-making. Third, across all cases, EL was most commonly coordinated with NL, while PL and

SL appeared selectively, typically when teachers explicitly oriented students toward representational transitions. Digitally mediated embodied action (EL3) was not observed in the dataset. The following case descriptions illustrate how these patterns were enacted in classroom practice, highlighting qualitatively different roles of EL across instructional contexts

Cases 1 and 2 (Teacher 1, Grade 4): EL as a bridge to abstraction

These lessons foregrounded EL to support abstraction in learning *large numbers* and *measurement relationships*. In Case 1, tactile–manipulative structuring (EL1) supported number magnitude as students built numbers with ten blocks while verbally negotiating solutions. Playful embodied engagement (EL5) was used through skip-counting games, and spatial–embodied structuring (EL2) emerged when students physically constructed a number line. Case 2 extended this orchestration to larger numbers and measurement, emphasizing decomposing 10,000 and scaling relationships. Students coordinated EL with verbal and symbolic reasoning through multiple decompositions and measurement tasks, including modeling length with clips and physically linking units.

Cases 3 and 4 (Teacher 2, Grade 2): EL as structured sense-making

These lessons focused on *number sequences* and *two-digit numbers* and provide a clear example of systematic orchestration of EL across instructional phases. In Case 3, playful embodied engagement (EL5) was introduced through a brief transition activity in which students placed missing numbers on a hundred chart while justifying numerical relationships, followed by a short rhythmic and gestural activity (EL4) involving stomping, clapping, and counting by fives. In the longer phases, EL1 became central as students grouped and reorganized materials while verbalizing and writing place-value strategies; errors were addressed through embodied reconfiguration, making conceptual correction visible and discussable. Short phases functioned as routine-based embodied practices, whereas longer phases supported collective sense-making, highlighting both pedagogical value and time-management demands.

A similar orchestration pattern was observed in Case 4. EL1 introduced in individual and small-group work was extended to whole-class discussion through EL5. Notably, a student receiving special support re-engaged during a floor-based number-line activity involving spatial–embodied structuring (EL2), illustrating how whole-body positioning and social orchestration can broaden access to mathematical meaning.

Case 5 (Teacher 3, Grade 2): EL as procedural reinforcement

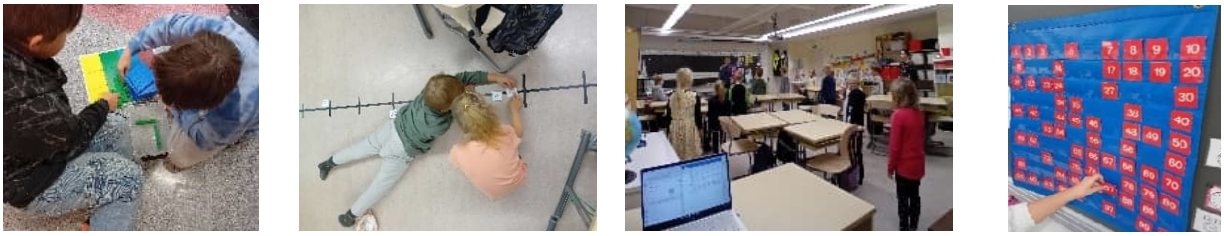
In this lesson, EL primarily supported procedural fluency in subtraction with regrouping (e.g., 45 − 7). The lesson unfolded across three phases. In P1, prior knowledge (“40 − 5”) was connected to the target task through whole-class demonstration using unit blocks and individual boards (EL1), coordinated with NL, PL, and SL. In P2 and P3, students applied the same decomposition strategy during individual and textbook work. Across phases, EL reinforced a consistent procedure

(e.g., “45 − 5 − 2”). A critical episode highlighted a limitation of this orchestration: one student produced an incorrect result (“50 − 2 = 84”) through finger counting but responded correctly when the task was verbally recontextualized. This episode suggests that EL, when weakly coordinated with other semiotic modes, may support fluency without ensuring conceptual understanding.

Coordination of EL with other semiotic modes

Figure 2 illustrates how domains of Embodied Language (EL) were coordinated with other semiotic modes during classroom interaction. The four panels present selected examples from Cases 1, 3, and 4, highlighting tactile, spatial, rhythmic, and playful forms of embodied participation embedded within instructional sequences.

Figure 2: Examples of Embodied Language coordination in instruction (A–D).



(A) (B) (C) (D)

(A) *EL1 Tactile–manipulative structuring* (Case 1, P2): Students built numbers from 1 to 100 using ten blocks, taking turns to touch, construct, and explain their solutions. EL was coordinated with natural language (NL) through peer negotiation and teacher questioning, and with symbolic language (SL) through numerical representations.

(B) *EL2 Spatial–embodied structuring* (Case 4, P4): Students placed number cards on a floor number line, using whole-body positioning to represent numerical magnitude. EL was coordinated with NL, pictorial language (PL), and SL through individual questioning and shared visual reference.

(C) *EL4 Rhythmic and gestural embodiment* (Case 3, P2): Students stomped, clapped, and verbally counted by fives in a whole-class activity. EL was coordinated with NL through forward and backward counting explicitly linked to numerical structure.

(D) *EL5 Playful embodied engagement* (Case 3, P1): Students identified missing numbers on a hundred chart through pointing and movement during a transition activity. EL was coordinated with NL, PL, and SL as students justified their reasoning by identifying neighboring numbers.

DISCUSSION AND CONCLUSION

The findings demonstrate that EL is not pedagogically meaningful by its mere presence, but through intentional orchestration within instructional sequences (Way & Ginns, 2024). Across cases, EL functioned in qualitatively different ways: as a bridge to abstraction, as structured sense-making, and as procedural support.

Differences across EL domains highlight their uneven pedagogical uptake. Tactile–manipulative (EL1) and spatial–embodied structuring (EL2) supported students' externalization of grouping, decomposition, and place-value relationships, consistent with research emphasizing embodied learning as epistemically meaningful when coordinated with representational transitions (Palatnik et al., 2023). In contrast, digitally mediated embodied action (EL3) was largely absent, indicating an unrealized pedagogical opportunity rather than a limitation of the domain itself (Abrahamson et al., 2020). Rhythmic and playful embodiment (EL4, EL5) showed particular promise: movement-based activities supported re-engagement and participation, especially for students requiring additional support, by offering alternative, non-verbal entry points to mathematical meaning (Hannula, 2012; Krause & Shvarts, 2022).

The findings also reveal practical tensions in classroom implementation. Embodied activities—especially novel games or movement patterns—required additional time for explanation and coordination. However, when established as routine practices, rhythmic and play-based EL supported efficient transitions and sustained engagement, suggesting that time-management challenges can be mitigated through accumulated instructional experience. Moreover, combining EL with diverse working formats (individual, pair, group, whole-class) supported participation among socially or attentively diverse learners.

This study advances Languaging approaches by conceptualizing EL as a multi-domain semiotic resource whose epistemic value depends on task design, mode transitions, and instructional positioning. Rather than treating bodily activity as merely motivational, the findings demonstrate that routine movement, manipulatives, and play-based actions can function as core sense-making resources when intentionally orchestrated with verbal, pictorial, and symbolic modes.

The study is limited by its small qualitative dataset from Finnish classrooms familiar with Languaging approaches, the absence of longitudinal learning measures, and overlap among analytically defined EL domains. Future research should examine how EL orchestration develops over time, how students appropriate embodied resources for independent reasoning, and how cultural and curricular contexts shape the pedagogical role of embodiment.

Overall, this study demonstrates that Embodied Language is not simply "movement" or "play," but a powerful pedagogical resource for supporting sense-making and participation in primary mathematics when embedded in intentional instructional design.

Additional information

This study forms part of a doctoral dissertation supervised by Professor Jorma Joutsenlahti (Tampere University) and Professor Päivi Perkkilä (University of Turku).

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