

Effects of Embodied Cognition Through Arts-Based Strategies in Developing Mathematical Competencies of Grade 7 Learners of Leonarda D. Vera Cruz National High School

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Abstract

This study examined the effects of embodied cognition through arts-based strategies on the mathematical competencies of Grade 7 learners at Leonarda D. Vera Cruz National High School, Unisan, Quezon, Philippines. Grounded in Embodied Cognition Theory and an Input–Process–Output–Outcome framework, the study employed a descriptive quasi-experimental, single-group pretest–posttest design involving 26 Grade 7 learners during School Year 2025–2026. Data were collected using a researcher-developed, validated 20-item competency test and analyzed through mean scores, mean percentage scores (MPS), standard deviations, learning gains, and paired-samples t-tests. The intervention incorporated movement, gestures, artistic expression, and kinesthetic activities to develop three mathematical competencies. Results revealed improvements in using positive and negative numbers to describe directions or opposites (38.46% to 73.63%), locating integers on a number line (41.67% to 91.03%), and performing addition and subtraction of integers (19.78% to 58.24%). The respective learning gains were 35.17, 49.36, and 38.46 percentage points, with a reported overall mean gain of 41.00 percentage points. Statistically significant pretest–posttest differences were observed across all competencies ($p < .001$). Locating integers demonstrated the greatest improvement, while integer operations remained the most challenging competency. The findings supported the development of a Mathematics 7 lesson exemplar integrating arts-based activities, movement, and formative assessments. Although the absence of a comparison group limits causal interpretation, the results suggest that embodied arts-based instruction is a promising approach to strengthening mathematical understanding. The study aligns with Sustainable Development Goal 4 (Quality Education) by supporting learner-centered approaches to foundational numeracy. Its educational sustainability contribution lies in providing a structured instructional resource that may support continued teaching improvement and meaningful Mathematics learning.

Keywords: Arts-Based Strategies; Embodied Cognition; Grade 7 Learners; Integer Operations; Mathematical Competencies; Mathematics Education; Quasi-Experimental Design

1. Introduction

Mathematics is essential for developing learners' reasoning, problem-solving, and numerical competencies. However, Filipino learners continue to experience difficulties in understanding abstract mathematical concepts, as reflected in the country's performance in PISA 2022 (Organisation for Economic Co-operation and Development, 2023). Traditional instruction emphasizing memorization and procedural knowledge may limit conceptual understanding (Gordon & Ramani, 2021; Hurrell, 2021). Embodied cognition through arts-based strategies offers an alternative approach by integrating movement, gestures, dance, and kinesthetic activities into Mathematics instruction. This study examines the effects of these strategies on selected integer competencies among Grade 7 learners at Leonarda D. Vera Cruz National High School.

Embodied cognition emphasizes the relationship between physical experiences and cognitive processes in developing mathematical understanding (Abrahamson, 2020). Integrating movement, gestures, and concrete representations enables learners to connect abstract mathematical concepts with meaningful experiences (Way and Ginns, 2024). Liu et al. (2025) reported positive effects of embodied learning on mathematical competencies, while Zhao et al. (2024) highlighted the benefits of arts integration in improving conceptual understanding and engagement.

Arts-based strategies, including dance, visual arts, gestures, and movement, provide interactive approaches to Mathematics instruction. Studies indicate that physical movement and creative representations improve learners' understanding of mathematical relationships and integer operations (Cunningham and Lee, 2021; Hawkins and Robins, 2022; Tatum and Martino, 2023). Kinesthetic activities also support engagement, retention, and problem-solving by connecting physical experiences with abstract concepts (Indriani et al., 2023; Williams and Dewar, 2022).

The MATATAG Curriculum emphasizes conceptual understanding and practical applications of Mathematics. This study focuses on three Grade 7 competencies: using positive and negative numbers to describe directions or opposites, locating integers on a number line, and performing addition and subtraction of integers. Research suggests that contextualized movement, number-line activities, and visual representations strengthen integer understanding (Akyüz and Güveli, 2025; Anton et al., 2024). The study examines these competencies among Grade 7 learners at Leonarda D. Vera Cruz National High School, Division of Quezon.

The study is grounded in Embodied Cognition Theory, which recognizes the influence of bodily movement, sensory experiences, and environmental interaction on learning (Barsalou, 2020). Physical activities provide concrete representations that support abstract mathematical reasoning (Wilson, 2020; Nathan et al., 2021). The study applies an Input–Process–Output–Outcome framework to examine learners' initial competencies, implementation of arts-based embodied strategies, post-intervention performance, and development of a lesson exemplar.

Although previous studies demonstrate the benefits of embodied and arts-integrated Mathematics instruction, evidence concerning its application to specific Grade 7 integer competencies in the local context remains limited (Johnson et al., 2024; Lyu and Deng, 2024). Challenges involving instructional resources, teacher preparation, and alignment with learning objectives also require consideration (Perez and Wang, 2023). This study addresses these concerns by examining learners' pretest and posttest performance, gain scores, and significant differences in mathematical competencies following the intervention.

The study supports SDG 4: Quality Education by examining an inclusive, learner-centered instructional approach intended to improve foundational numeracy. Integrating arts and movement into Mathematics instruction provides alternative opportunities for learners to understand abstract concepts, participate actively, and develop essential mathematical competencies.

The study contributes to educational sustainability by exploring innovative, multidisciplinary approaches that integrate Mathematics, arts, and kinesthetic learning. Its findings may support improved instructional practices, while the proposed lesson exemplar may provide teachers with a practical resource for strengthening Grade 7 mathematical competencies. These contributions may promote sustained instructional improvement and learner-centered educational practices.

2. Material and methods

2.1 Research Design

The study utilized a descriptive quasi-experimental, single-group pretest–posttest design to evaluate the effects of embodied cognition through arts-based strategies on Grade 7 mathematical competencies. This design allows researchers to assess instructional interventions in natural classroom settings without random assignment (Johnson and Christensen, 2021). The intervention integrated body movement, kinesthetic activities, and artistic expression

to develop learners' understanding of positive and negative numbers in real-life situations, locating integers on a number line, and performing integer addition and subtraction. Learners' pretest and posttest scores were compared to determine changes in mathematical competency following the intervention.

2.2 Locale of the Study

The study was conducted at Leonarda D. Vera Cruz National High School, located in Barangay Panaon Ibaba, Unisan, Quezon, under the Schools Division of Quezon, Region IV-A (CALABARZON), Philippines. The school was selected because it offers Grade 7 Mathematics, provides an appropriate instructional environment for implementing arts-based embodied cognition strategies, and is accessible for data collection. Its classroom setting enabled the researcher to examine the intervention under actual teaching and learning conditions.

2.3 Respondents of the Study

The respondents comprised 26 Grade 7 learners from the Sampaguita section at Leonarda D. Vera Cruz National High School during School Year 2025–2026. All participants were officially enrolled and experienced the same classroom environment and instructional intervention. Their mathematical competencies were assessed before and after implementation using a validated competency test. Participant identities were protected through coded identifiers, and results were reported in aggregate form.

2.4 Sample and Sampling Procedure

The study involved 26 of the 40 officially enrolled Grade 7 learners from the Sampaguita section. Participants were drawn from a single intact classroom group without random assignment. This arrangement allowed the intervention to be implemented within the existing instructional setting while maintaining comparable classroom conditions. The original methodology did not specify the criteria used to select the 26 participants from the class of 40.

2.5 Research Instrument

The primary research instrument was a researcher-developed, validated 20-item pretest and posttest designed to assess the selected Grade 7 Mathematics competencies. A Table of Specifications guided its development to ensure alignment with the MATATAG Curriculum. Lesson exemplars integrating embodied cognition through arts-based strategies were also prepared as instructional materials. The assessment instruments and lesson exemplars underwent content and face validation by experts who evaluated their clarity, relevance, appropriateness, and curriculum alignment. Recommendations were incorporated into the revised materials, which were subsequently pilot-tested among Grade 7 learners from the Orchid section. The assessment tools were evaluated by a Master Teacher I from Lopez Comprehensive National High School and a Mathematics Teacher II from Leonarda D. Vera Cruz National High School.

2.6 Data Gathering Procedure

Data collection involved three phases: preparation, implementation, and post-implementation. During preparation, the researcher secured permission from the Schools Division Superintendent and School Principal, explained the study to the learners, obtained voluntary participation, and validated the research instruments. A pretest was then administered to establish learners' baseline mathematical competencies. During implementation, learners participated in Mathematics lessons incorporating embodied cognition through arts-based strategies, particularly body movement and kinesthetic activities aligned with the three selected integer competencies. Following the intervention, the same group completed a posttest to measure changes in mathematical performance. The pretest and posttest results were analyzed to determine learning gains and differences in competency levels. Findings also informed the refinement of the proposed lesson exemplars.

2.7 Data Analysis Techniques

The collected data were analyzed using descriptive and inferential statistics. Mean, Mean Percentage Score (MPS), and standard deviation were employed to determine learners' mathematical competencies before and after the intervention. The MPS represented competency levels, while standard deviation measured score variability. The competency interpretation followed seven descriptive categories: Mastered (96%–100%), Closely Approximating Mastery (86%–95%), Moving Towards Mastery (66%–85%), Average (35%–65%), Low (15%–34%), Very Low (5%–14%), and Absolutely No Mastery (0%–4%). These classifications, presented in Table 1 of the original manuscript, provided the basis for interpreting pretest and posttest performance. Mean gain scores were computed by subtracting the pretest MPS from the posttest MPS to determine learners' improvement following the intervention. A paired-samples t-test was employed to determine whether a statistically significant difference existed between pretest and posttest competency levels.

2.8 Ethical Considerations

The study observed ethical principles concerning voluntary participation, learner welfare, confidentiality, fairness, and academic integrity. Necessary institutional permissions were secured, and participants were informed about the study before participation. Personal information was protected through coded identifiers, and findings were reported in aggregate form. The researcher maintained objectivity and transparency throughout data collection, analysis, and reporting. No financial, professional, personal, or institutional conflicts of interest were declared.

3. Results and Discussion

3.1 Mathematical Competencies Before and After the Intervention

3.1.1 Using Positive and Negative Numbers to Describe Directions or Opposites

The learners' mean score increased from 2.69 (SD = 1.81) in the pretest to 5.15 (SD = 1.26) in the posttest, yielding a mean gain of 2.46. The mean percentage score (MPS) increased from 38.46% (Average) to 73.63% (Moving Towards Mastery), representing a gain of 35.17 percentage points. Before the intervention, 15 learners (57.69%) were classified under Low, Very Low, or Absolutely No Mastery. After the intervention, five learners (19.23%) achieved Mastered, six (23.08%) reached Closely Approximating Mastery, and no learners remained in the three lowest categories. The improvement suggests that movement-based activities, particularly the Human Number Line, supported learners in understanding positive and negative numbers through physical positioning and directional movement. These findings align with Way and Cartwright (2023), Way and Ginns (2024), and Bjørnebye and van Bommel (2025), who emphasized the contribution of bodily movement and spatial representations to mathematical understanding. However, Núñez (2012) cautioned that physical activities require explicit instruction and guided reflection to establish meaningful mathematical relationships.

3.1.2 Locating Integers on a Number Line

Learners demonstrated substantial improvement in locating integers on a number line. The mean score increased from 2.50 (SD = 1.08) to 5.46 (SD = 1.05), producing a gain of 2.96. The MPS increased from 41.67% (Average) to 91.03% (Closely Approximating Mastery), equivalent to a 49.36-percentage-point gain. Before the intervention, 14 learners (53.85%) were classified as Low, while none achieved Mastered. Following the intervention, 19 learners (73.08%) achieved Mastered, representing the highest posttest performance among the three competencies. The findings suggest that the Find Your Home activity and Snake and Ladder Game supported learners in visualizing integer positions through movement and spatial interaction. This observation is consistent with Anton and Abrahamson's 2024 research, Fischer and Shaki (2024), and Gerofsky (2025), which highlighted the contribution of physical movement to understanding numerical magnitude and direction. Nevertheless, Kirsh (2021) and Nathan and Walkington (2022) emphasized that movement must be deliberately connected to mathematical reasoning rather than functioning solely as an engaging classroom activity.

3.1.3 Performing Addition and Subtraction of Integers

The mean score for integer addition and subtraction increased from 1.38 (SD = 1.11) to 4.08 (SD = 1.33), with a mean gain of 2.70. The MPS improved from 19.78% (Low) to 58.24% (Average), reflecting a gain of 38.46 percentage points. Initially, no learners reached Moving Towards Mastery or higher. Following the intervention, two learners (7.69%) achieved Mastered, one (3.85%) reached Closely Approximating Mastery, four (15.38%) attained Moving Towards Mastery, and 16 (61.54%) achieved Average. Although performance improved, this competency recorded the lowest posttest MPS. The improvement may be associated with the Integers Dance Party, Interactive Number Line Challenge, and Integer Operation Relay Challenge, which allowed learners to represent integer operations through movement and collaboration. These findings support O'Donnell and McNally (2021), and Jackson and White (2022), who emphasized the role of physical representations in mathematical understanding. However, Thompson and Rivera (2023) and Garcia and Lee (2024) suggested that embodied activities may not consistently improve computational mastery without explicit instruction and repeated procedural practice.

3.2 Learning Gains Across the Three Mathematical Competencies

The learners demonstrated positive gains across all three competencies following the intervention. Understanding positive and negative numbers increased from 38.46% to 73.63%, yielding a gain of 35.17 percentage points. Locating integers on a number line improved from 41.67% to 91.03%, producing the highest gain of 49.36 percentage points. Addition and subtraction of integers increased from 19.78% to 58.24%, representing a gain of 38.46 percentage points. The reported mean gain across the three competencies was 41.00 percentage points. These improvements suggest that embodied cognition through arts-based strategies supported learners' understanding of integer concepts, particularly those involving spatial and directional relationships. The findings are consistent with Lobo and Hedges (2023), Abrahamson et al. (2021), and Shapiro et al. (2024), who emphasized the contribution of movement and sensory experiences to mathematical understanding. Smith et al. (2023) similarly reported improved integer operations through movement-based instruction. However, Bicer, Capraro, and Capraro (2021), Bakker and Wagner (2023), Fyfe and Nathan (2021), and Alibali and Nathan (2022)

emphasized the importance of structured guidance, conceptual connections, and symbolic practice in achieving sustained mathematical understanding.

3.3 Significant Differences Between Pretest and Posttest Competencies

Paired-samples t-tests revealed statistically significant differences between pretest and posttest scores across all three competencies. For describing directions or opposites using positive and negative numbers, the mean paired difference was -35.16192 , $t(25) = -15.467$, $p < .001$, with a 95% confidence interval of $[-39.84397, -30.47988]$. For locating integers on a number line, the mean paired difference was -49.35962 , $t(25) = -17.338$, $p < .001$, with a 95% confidence interval of $[-55.22296, -43.49627]$. For integer addition and subtraction, the mean paired difference was -39.00846 , $t(25) = -19.225$, $p < .001$, with a 95% confidence interval of $[-43.18726, -34.82966]$. All comparisons were statistically significant, resulting in rejection of the null hypothesis. The negative mean differences indicate higher posttest scores because the paired differences were calculated by subtracting posttest scores from pretest scores. The findings demonstrate significant improvements following the intervention, with the greatest mean difference observed in locating integers on a number line. These results are consistent with Wei (2025) and Johnson et al. (2024), who reported favorable outcomes from embodied Mathematics instruction. Nevertheless, Fyfe et al. (2021) and Carbonneau et al. (2023) emphasized that meaningful learning gains depend on aligning physical activities with mathematical objectives and opportunities for reflection. Given the single-group design, the findings establish significant pretest–posttest improvement but do not independently establish that the intervention caused these changes.

3.4 Development of the Mathematics 7 Lesson Exemplar

Based on the findings, a Mathematics 7 lesson exemplar was developed to integrate embodied cognition through arts-based strategies into classroom instruction. The exemplar covers nine of the 14 competencies identified in the manuscript across Measurement and Geometry and Numbers and Algebra. It incorporates interactive discussions, movement-based activities, drawing, visual representations, and formative assessments. Supporting instruments include an Implementation Fidelity Observation Checklist, Learner Impact Rating Sheet, Teacher Reflection Journal, and Pretest/Posttest Summary Tracker. The lesson exemplar provides a structured instructional resource intended to strengthen conceptual understanding, engagement, and active participation. Its formative assessments and monitoring instruments support teachers in identifying learners who require additional instruction and adjusting activities according to learning needs. The exemplar also integrates cognitive, psychomotor, and affective objectives to promote meaningful mathematical learning through creative and physical experiences.

4. Conclusion & Recommendations

The study demonstrated significant improvements in the mathematical competencies of Grade 7 learners following the implementation of embodied cognition through arts-based strategies. The mean percentage scores increased by 35.17 percentage points in using positive and negative numbers to describe directions or opposites, 49.36 percentage points in locating integers on a number line, and 38.46 percentage points in performing addition and subtraction of integers, with an overall mean gain of 41.00 percentage points. Paired-samples t-tests revealed statistically significant differences between pretest and posttest scores across all three competencies ($p < .001$). The greatest improvement was observed in locating integers on a number line, while integer addition and subtraction remained the most challenging competency. The findings supported the development of a Mathematics 7 lesson exemplar integrating movement, artistic expression, and interactive activities to promote meaningful, learner-centered instruction.

Mathematics teachers are encouraged to integrate embodied cognition through arts-based strategies into classroom instruction, particularly when teaching abstract mathematical concepts. Additional guided practice, enrichment activities, and targeted instructional support should be provided to strengthen learners' proficiency in integer addition and subtraction. Teachers may also develop, adapt, and utilize arts-integrated lesson exemplars across different mathematical competencies and grade levels. Future researchers are encouraged to involve larger and more diverse populations, extend the intervention period, incorporate control or comparison groups, and investigate additional mathematical competencies and learning outcomes, including retention, motivation, confidence, and attitudes toward Mathematics.

The study was limited to 26 Grade 7 learners from Leonarda D. Vera Cruz National High School and focused on three mathematical competencies involving positive and negative numbers, number-line representation, and integer operations. Its single-group quasi-experimental design, without a control or comparison group, limited the ability to attribute observed improvements exclusively to the intervention. The restricted sample and educational setting also limited the generalizability of the findings. Furthermore, the study primarily assessed mathematical competency through pretest and posttest performance and did not examine long-term retention, motivation, confidence, or attitudes toward Mathematics.

5. Compliance with ethical standards

The researcher declares no conflict of interest, and the study was conducted solely for academic purposes; external funding was not specified. The researcher acknowledges the participation of the Grade 7 learners and the cooperation of Leonarda D. Vera Cruz National High School, Unisan, Quezon. Participation was voluntary, informed consent was obtained, and data were collected through non-invasive educational assessments. Participant confidentiality was maintained through coded identifiers, and no personally identifying information was disclosed in the reported findings.

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