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DEVELOPING MATHEMATICAL THINKING IN PRESCHOOL CHILDREN THROUGH MUSICAL RHYTHM, REPETITION, AND SYMMETRY

Saodat E. Farkhodova
Grade 9 student, Khiva City Specialized School No. 2, Uzbekistan
xivagsm555@gmail.com
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Abstract: This article examines a non-standard yet theoretically well-grounded pedagogical approach to shaping mathematical thinking in preschool-age children through musical activity. Musical rhythm, melodic repetition, and compositional symmetry are analyzed as didactic tools that may help children naturally acquire mathematical skills such as counting and sequencing, number constancy, and grouping. The study is conceptual in nature: it synthesizes developmental theory (Vygotsky, Piaget) and empirical findings from the international music-education literature to propose a structured pedagogical model, in which rhythmic clapping, rhyming counting songs, and symmetrical movement activities are mapped onto specific mathematical concepts. A four-stage instructional cycle-listen and move, recognize the pattern, predict the continuation, and internalize the concept- is introduced together with a set of qualitative, three-level assessment indicators (number-sequence recitation, pattern continuation, and grouping). The article does not report original experimental data; rather, it provides the theoretical and methodological foundation required for a future empirical pilot study, and outlines the practical recommendations that preschool educators can already apply. The proposed model is discussed in relation to existing international research, including its documented limitations and mixed findings, in order to present a balanced and academically honest account of the approach's potential and its boundaries.

Keywords: preschool education; mathematical thinking; musical rhythm; repetition; symmetry; pattern recognition; early childhood pedagogy; pedagogical design.

INTRODUCTION

The preschool stage is one of the most delicate and decisive periods in the formation of a child's intellectual potential. At this age, a child's thinking is largely concrete and image-based, so abstract concepts are absorbed far more effectively through active movement and play involving the senses than through direct verbal explanation [1, 2].For this reason, pedagogy and developmental psychology have shown growing interest in recent years in developing children's mathematical thinking through non-standard, creative means, music being one of the most promising among them [3].

Music is, by its nature, a phenomenon rich in mathematical properties: any rhythm is built on the regular repetition of a time interval, while melody is frequently organized around symmetrical structure. Concepts such as beat, meter, rhyme, and musical form are, in essence, expressions of mathematical categories such as counting, grouping, sequencing, and pattern. Musical activity-singing, rhythmic clapping, playing instruments, dancing-therefore offers children a way of experiencing the world of numbers and shapes through play, rather than through repetitive drilling.

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The relevance of the problem lies in the fact that, in conventional preschool practice, mathematical concepts are often taught in isolation, within a separate "counting lesson," which can diminish a child's natural curiosity and foster a negative attitude toward mathematics. Teaching music and mathematics in an integrated way, by contrast, is expected to increase a child's emotional engagement and turn the learning process into a meaningful experience.

The purpose of this study is to propose and theoretically justify a pedagogical model for using musical rhythm, repetition, and symmetry to support the core indicators of mathematical thinking-understanding of numerical sequence, pattern continuation, and grouping skills-in children aged 5-6, and to outline the methodological groundwork required for its future empirical evaluation.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The central role of activity and play in the development of a child's thinking is grounded in Vygotsky's cultural-historical theory, according to which higher mental functions first emerge as external, social activity before becoming internalized as thought [1]. Piaget similarly demonstrated that a preschool child's cognitive activity is shaped through concrete actions and sensory experience [2]. Together, these two theories provide a foundation for why musical-rhythmic activity may create a favorable environment for acquiring mathematical concepts in an embodied, "enacted" form. Gardner's theory of multiple intelligences further supports treating musical and logical-mathematical abilities as related but distinct domains that can reinforce one another through appropriately designed activity [3].

Among empirical studies, Geist and Geist examined the role of songs and counting rhymes in shaping children's understanding of number sequence and numerical constancy [4].Rauscher and Zupan found that children who received regular keyboard instruction showed higher spatial-temporal reasoning scores than a control group [5].An, Tillman, and colleagues, working with elementary school students, reported that music-mathematics integrated lessons had a positive effect on students' disposition toward mathematics [6]. Zentner and Eerola experimentally demonstrated that even infants exhibit active physical responsiveness to rhythm, suggesting that rhythmic sensitivity is present from a very early age [7].Hallam's broader review situates these findings within the wider evidence on music's role in intellectual and social development [8].

At the same time, the literature on music training and academic transfer is not uniformly positive: a multilevel meta-analysis by Sala and Gobet found that the cognitive and academic benefits of music training in children are generally small and inconsistent once study quality and control conditions are accounted for [9]. This suggests that any benefit of music-integrated mathematics activities is more likely to stem from the deliberate, structured pairing of specific musical elements (rhythm, repetition, symmetry) with specific mathematical concepts, rather than from music exposure in general-a distinction that directly motivates the structured model proposed below.

Source	Focus	Relevance to the proposed model

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Source	Focus	Relevance to the proposed model
Geist & Geist [4]	Counting songs and rhymes	Supports the use of rhyming counting songs for sequencing
Rauscher & Zupan [5]	Keyboard instruction, spatial-temporal reasoning	Supports structured, regular musical practice
An et al. [6]	Music-mathematics integrated lessons	Supports integration rather than isolated "counting lessons"
Zentner & Eerola [7]	Rhythmic responsiveness in infancy	Suggests rhythm sensitivity as a developmental starting point
Sala & Gobet [9]	Meta-analysis of music training transfer	Cautions against overgeneralizing; motivates targeted design

METHODOLOGY OF MODEL DESIGN

Given the absence, at this stage, of an original empirical dataset, the study follows a pedagogical design methodology:a conceptual model is constructed from developmental theory and prior empirical findings, structured for future piloting rather than presented as already validated.

Design stages

1.Theoretical analysis-review of developmental theories of concrete, activity-based learning [1, 2] and the theory of multiple intelligences [3].

2.Evidence synthesis-review of empirical studies on music and mathematical/cognitive development, including both supportive [4-8] and cautionary [9] findings.

3.Correspondence mapping-explicit mapping of three musical elements (rhythm, repetition, symmetry) onto three mathematical concepts (sequencing, number constancy/pattern, grouping/spatial relations) (Figure 1).

4.Instructional cycle design-formulation of a four-stage pedagogical cycle describing how a musical activity is expected to lead to internalization of a mathematical concept (Figure 2).

5.Assessment framework design-development of three qualitative indicators with a three-level descriptive scale, intended for use in a future pre-/post-intervention pilot study.

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Figure 1. Correspondence between musical elements and mathematical concepts

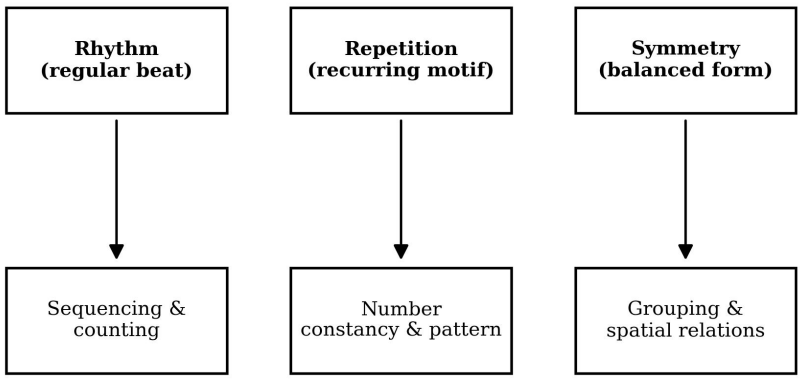


Figure 1. Correspondence between musical elements and mathematical concepts

Intended pilot design (for future research)

The model is intended to be tested in a future quasi-experimental pilot involving experimental and control groups of children aged 5-6, with sessions incorporating rhythmic counting through clapping, rhyming counting songs, and symmetrical movement activities (right-left, forward-backward combinations), assessed against a conventional-instruction control group. No such pilot has yet been conducted; the present article establishes the theoretical and methodological basis on which it would be built.

THE PROPOSED PEDAGOGICAL MODEL

The proposed model organizes musical-mathematical activity into a four-stage cycle: children listen and move to a rhythmic or melodic stimulus, recognize the pattern it contains, predict how the pattern should continue, and, through repetition across sessions, internalize the corresponding mathematical concept (Figure 2).

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Figure 2. Proposed music-based pedagogical cycle

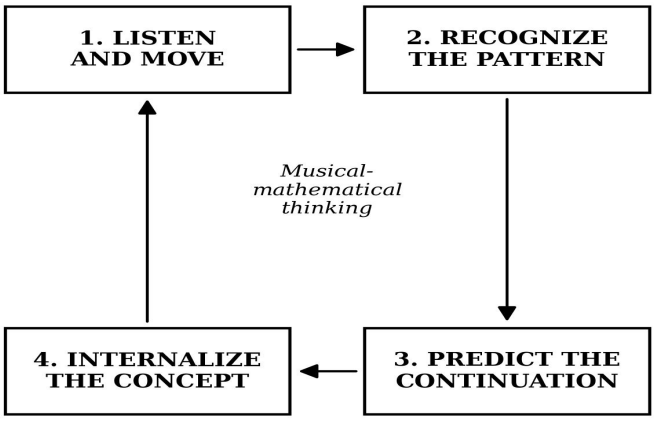


Figure 2. Proposed music-based pedagogical cycle

Three categories of activity are proposed as the core content of the model: rhythmic counting through clapping (e.g., coordinated "one-two, clap-clap" sequences) to support number sequencing; rhyming counting songs to reinforce number constancy and verbal-numerical pattern; and symmetrical dance movements (right-left, forward-backward combinations) to embody grouping and basic spatial relations.

To support future evaluation of the model, three qualitative indicators are proposed, each accompanied by a three-level descriptive scale (Table 2).

Indicator	Low level	Medium level	High level
Number-sequence recitation (1–10)	Recites with frequent errors or support	Recites with occasional errors	Recites independently and without error
Pattern continuation	Cannot continue a simple pattern	Continues a pattern with prompting	Continues and explains a pattern independently
Grouping by attribute	Groups only with adult assistance	Groups correctly with occasional help	Groups independently by more than one attribute

Together, the correspondence map, the instructional cycle, and the assessment framework constitute a complete, pilot-ready methodological model, which does not itself require specialized equipment and can, in principle, be implemented within the daily routine of any preschool institution.

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DISCUSSION

The proposed model is consistent with the theoretical positions of Vygotsky and Piaget on activity-based learning, and it operationalizes, in a preschool context, the empirical associations reported by Geist and Geist, Rauscher and Zupan, and An and colleagues between musical activity and early mathematical or spatial-temporal skills [4-6]. The pedagogical rationale is that rhythm, being temporally ordered repetition, may allow a child to "feel" the sequential property of counting through physical movement and auditory experience,while symmetrical movement may present spatial relations and grouping logic as directly embodied experience.

At the same time, the meta-analytic evidence reviewed above indicates that transfer effects from music training to academic domains are often small and inconsistent once methodological quality is controlled for [9]. This is an important caution: the present model should not be read as a guarantee of measurable mathematical gains, but as a theoretically motivated, low-cost pedagogical design whose actual effectiveness remains to be established. Any future pilot study should therefore include an appropriately matched control group, a validated assessment instrument, and a sample size sufficient for meaningful statistical comparison-conditions that were deliberately left unspecified in the present conceptual article.

Practically, even in the absence of empirical confirmation, the model offers preschool educators a structured, low-resource way of embedding rhythmic counting games, rhyming verses, and symmetrical movement into daily routines, positioned as a complement to, rather than a replacement for, conventional mathematics instruction.

CONCLUSION

This article proposed a theoretically grounded pedagogical model linking musical rhythm, repetition, and symmetry to the development of numerical sequencing, pattern recognition, and grouping skills in preschool children. The model comprises an explicit correspondence map between musical elements and mathematical concepts, a four-stage instructional cycle, and a three-level qualitative assessment framework.

In summary:(1) musical-rhythmic activity offers a theoretically plausible, playful route to core early mathematical concepts; (2) rhythm and symmetry can serve as a conceptual "bridge" to sequencing and grouping logic, though existing meta-analytic evidence urges caution against overstated claims of transfer;(3) the approach requires no specialized equipment and can, in principle, be embedded in daily preschool routines; and (4) empirical validation through a controlled pilot study, using real pre- and post-intervention data, is the necessary next step before any claim of pedagogical effectiveness can be made. Future work should prioritize conducting such a pilot with an adequately sized sample, a matched control group, and a validated, statistically analyzed outcome measure.

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