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FROM SEEING TO MEASURING:DEVELOPING MATHEMATICAL THINKING IN PRESCHOOL CHILDREN THROUGH SIMPLE PHYSICAL PHENOMENA

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Abstract: This article presents a methodological system for developing mathematical thinking in preschool children through the observation of simple physical phenomena, including light and shadow, the properties of water, weight, motion, and time. The relevance of the study is determined by the fact that, in current practice, mathematical concepts are frequently taught to preschool children through abstract, number-based exercises that do not fully correspond to their developmental characteristics, leaving the natural connection between physical experience and mathematical reasoning underused. The aim of the study was to design a coherent methodological system for children aged 3 to 6, based on an "observe-measure-think" cyclical model, comprising hands-on experiments and games, and to provide its theoretical-pedagogical justification. The study followed a pedagogical design research approach, in which the cognitive development theories of Piaget and Vygotsky, Montessori's sensorial pedagogy, and the contemporary STEAM concept were analyzed; on this basis, eight thematic blocks (observation, comparison, measurement, distance, time, weight, motion, and light-shadow/water properties) and 18 original game-based experiments were developed. As a result, a complete methodological system was produced that can be practically applied by preschool educators and is accompanied by explicit, three-level qualitative assessment criteria. The theoretical grounding of the system is discussed in comparison with internationally recognized approaches (Reggio Emilia, Montessori, the Finnish model), and directions for its future empirical piloting in preschool educational institutions are outlined. The findings may be of interest to preschool educators, methodologists, and researchers seeking accessible, evidence-informed tools for early mathematics education.

Keywords: early childhood education; mathematical thinking; physical phenomena;observation; measurement;STEAM;pedagogical design; preschool methodology.

INTRODUCTION

Early childhood is the most formative period during which a person's lifelong way of understanding the world takes shape. It is during this period that children discover the surrounding world through their senses, and in this process, the earliest elements of mathematical thinking-comparison, ordering, measurement, and understanding cause-and-effect relationships-begin to form. Nevertheless, in current practice, mathematical concepts in preschool educational institutions are frequently taught in isolation from children's direct experience, through abstract numbers and formal exercises, which contradicts the psychological characteristics typical of this age [1].

According to Piaget's theory of the preoperational stage, children aged 2 to 7 perceive the world predominantly through concrete, sensorially accessible images [1].Vygotsky's concept of the "zone of proximal development" further demonstrates that hands-on activity guided by adults is crucial for a child's future independent logical reasoning [2].These theoretical foundations confirm that the most effective way of shaping mathematical thinking in early childhood is through physical,

tangible experiences-specifically, activities built around the observation of simple physical phenomena.

In recent years, the STEAM (Science, Technology, Engineering, Arts, Mathematics) approach has become widespread in early childhood education worldwide, based on the premise that subjects should be presented to children as an integrated experience rather than as separate disciplines [3, 4]. Uzbekistan's national preschool curriculum, “Ilk Qadam,” likewise identifies the formation of natural-scientific and mathematical understanding through practical activity as a priority direction [5], a view echoed in the local methodological literature [6]. Nonetheless, local practice still lacks systematic, ready-to-use methodological tools that integrate physics and mathematics in a coherent way.

The aim of the present study was to design a complete methodological system for developing mathematical thinking in preschool children through the observation, comparison, and measurement of simple physical phenomena (light, shadow, water, weight, motion, and time), and to articulate its scientific-theoretical foundations.

The study sought to answer the following research questions: (1) which physical phenomena and types of activity are most appropriate for developing mathematical thinking in preschool children; (2)how can such activities be organized into a coherent methodological model; and (3) how does the developed system relate to internationally recognized pedagogical approaches?

METHODS

The study was conducted using a pedagogical design research methodology. This approach is oriented toward developing a new educational tool or system through stages of theoretical analysis, design, and structuring, and represents the pre-empirical stage of methodological development.

Stages of the study

1.Theoretical analysis stage-scientific literature on child developmental psychology [1, 2],sensorial pedagogy [7], and early mathematics learning trajectories [3] was reviewed and analyzed.

2.Curricular alignment stage-the system's compliance with national standards was ensured through comparison with the requirements of Uzbekistan's state preschool curriculum “Ilk Qadam” [5].

3.Principle formulation stage-a cyclical “observe-measure-think” model was developed, linking observation, comparison, measurement, and prediction into a single natural sequence (Figure 1).

4.Content structuring stage-based on the model, eight thematic blocks were developed, each accompanied by corresponding hands-on activities (experiments and games) (Figure 2).

5.Assessment tool development stage-qualitative criteria for tracking children's developmental progress, consistent with recommendations for developmentally appropriate assessment in early mathematics [8], were developed and accompanied by a three-level descriptive scale (low/medium/high).

Figure 1. The "Observe – Measure – Think" cyclical model

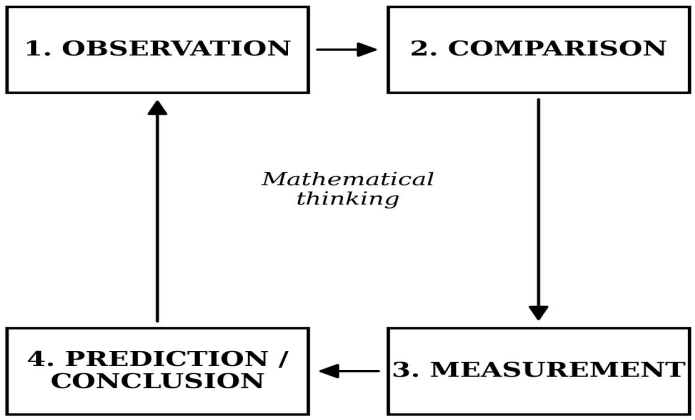


Figure 1.The "Observe -Measure-Think" cyclical model underlying the system

Target population of the system

The developed methodological system is intended for groups of children aged 3 to 6 in preschool educational institutions of the Republic of Uzbekistan, as well as for the educators working with them.A pedagogical pilot study to empirically test the system's effectiveness is planned as a subsequent stage of this research program; the present article reports the results of the system's design and theoretical justification stage.

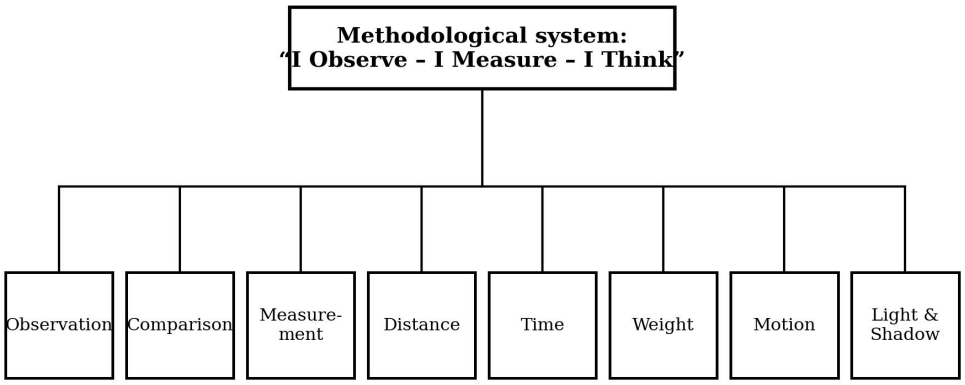
RESULTS

As a result of the study, a methodological system titled"I Observe-I Measure-I Think" was developed. At the core of the system lies a natural four-stage sequence of children's activity:observation→comparison→measurement→ prediction/conclusion.Based on this sequence, eight thematic blocks were formulated (Table 1, Figure 2).

Thematic block	Mathematical concept developed	Sample activity
Observation	Attention, feature discrimination	Daily observation of clouds and shadow movement
Comparison	Large–small, more–less relations	Comparing two or three objects by a given feature
Measurement	The concept of a non-standard unit	Measuring length/volume using steps or cups
Distance	Spatial and scale awareness	Directional movement, drawing

Thematic block	Mathematical concept developed	Sample activity
		simple maps
Time	Sequence and duration	Sand timers, daily-routine cards
Weight	Equality and inequality	Comparing objects on a two-pan balance
Motion	Speed and trajectory	Rolling objects on different surfaces
Light and shadow	Recognition of geometric shapes	Creating shadows with a flashlight

Figure 2. Structure of the eight thematic blocks within the system



Each block is implemented through hands-on games and experiments (18 activities), supported by five qualitative assessment criteria.

Figure 2. Structure of the eight thematic blocks within the system

For each block, hands-on activities were developed for direct work with children, culminating in a set of 18 original game-based experiments (for example, "Sink or Float?", "A Journey by Steps", and "The Colored Shadow Race"). Each game includes the following components: objective, recommended age group (3-4, 4–5, or 5-6 years), required materials, procedural steps, expected outcome, and an extended variant for older groups.

Five qualitative criteria were developed for tracking children's developmental progress: observational skill, comparison, measurement, prediction and verification, and verbal expression, in line with recommendations favoring qualitative, process-oriented assessment in early mathematics

education [11]. Each criterion is accompanied by a three-level descriptive scale-low, medium, and high (Table 2).

Criterion	Low level	Medium level	High level
Observational skill	Attends only when prompted	Occasionally notices changes independently	Independently notices new phenomena
Comparison	Compares by only one obvious feature	Compares by two or three features	Compares independently by several features
Measurement	Uses a tool only with adult help	Uses a simple tool with occasional help	Uses tools independently and compares results
Prediction	Struggles to make a prediction	Makes simple predictions in familiar cases	Is able to justify predictions
Verbal expression	Answers with "yes/no" only	Explains with a short phrase	Gives a full, logical explanation

The system was further complemented with recommendations for organizing a permanent "Little Researcher Corner" in the classroom, a sample monthly thematic plan, and family-engagement tools (a list of home-based experiments and a parent questionnaire template), forming a complete methodological guide.

DISCUSSION

The theoretical foundations of the developed system were examined in relation to internationally recognized pedagogical approaches (Table 3).

Approach / country	Core idea	Reflection in the developed system
Reggio Emilia (Italy)	The environment acts as the "third teacher"	The "Little Researcher Corner" concept
Montessori (international)	Independent learning through the senses	Tactile tools: balance scales, measuring instruments
Finnish model	Play-based learning; delayed formal assessment	Play-based activities; descriptive (non-numerical) assessment

Approach / country	Core idea	Reflection in the developed system
STEAM (international)	Integrated, cross-disciplinary experience	Unified observe–measure–think cycle across all eight blocks

A number of international studies indicate that early scientific and mathematical thinking develops more effectively through integrated, experience-based activity rather than through artificially separated domains [9, 3]. The findings of the present study corroborate these conclusions and extend them into a practical system adapted to local conditions, using inexpensive, readily available materials consistent with the "Ilk Qadam" curriculum [5] and national methodological literature [6, 10].

A limitation of the study is that the system has so far only passed through the theoretical-methodological design stage and has not yet been empirically tested through a real pedagogical pilot; confirming its effectiveness through statistical evidence remains the primary task for future research. How the system performs across different regions, language environments, and socio-economic conditions likewise warrants separate investigation.

CONCLUSION

The study resulted in the development of a complete methodological system for fostering mathematical thinking in preschool children through the observation of simple physical phenomena. Grounded in the developmental theories of Piaget and Vygotsky [1, 2], as well as the contemporary STEAM concept [3, 4], the system comprises eight thematic blocks, 18 original game-based experiments, and a set of assessment criteria, forming a coherent structure.

The practical significance of the system lies in its capacity to enable educators, without extensive theoretical preparation, to develop children's mathematical-physical thinking using simple and inexpensive materials. Future research should focus on empirically establishing the pedagogical effectiveness of the system through a controlled pilot study, as well as exploring opportunities to enrich it with digital tools such as interactive applications.

REFERENCES

1. Piaget, J. (1952). The Child's Conception of Number. London: Routledge.
2. Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.
3. Clements, D. H., & Sarama, J. (2020). Learning and Teaching Early Math: The Learning Trajectories Approach (3rd ed.). New York: Routledge.
4. English, L. D. (2016). STEM education K-12: Perspectives on integration. International Journal of STEM Education, 3(1), Article 3. https://doi.org/10.1186/s40594-016-0036-1
5. Ministry of Preschool Education of the Republic of Uzbekistan. (2022). State Preschool Education Curriculum "Ilk Qadam." Tashkent.

6. Mo'minova, L. R. (2019). Formation of Elementary Mathematical Concepts in Preschool Children. Tashkent: O'qituvchi.
7. Montessori, M. (1967). The Discovery of the Child. New York: Ballantine Books.
8. Sarama, J., & Clements, D. H. (2009). Early Childhood Mathematics Education Research: Learning Trajectories for Young Children. New York: Routledge.
9. Gopnik, A., Meltzoff, A. N., & Kuhl, P. K. (1999). The Scientist in the Crib: What Early Learning Tells Us About the Mind. New York: William Morrow.
10. Karimova, N. Sh. (2021). Innovative Pedagogical Technologies in Preschool Education. Tashkent.
11. National Council of Teachers of Mathematics. (2000). Principles and Standards for School Mathematics. Reston, VA: NCTM.