eISSN: 2229-3213 pISSN: 2229-3205
The Journal of Applied Science and Social Science
Volume 16,Issue 02 February, 2026

DEVELOPING SPATIAL THINKING AND LOGICAL REASONING THROUGH MÖBIUS STRIP MODELING IN PRESCHOOL

Gauxar Djanpeisova
Head of the Department of Preschool Education, Branch of the Russian State Pedagogical University named after A. I. Herzen in Tashkent, Professor
Ezoza Ubaydullaeva
a 3rd-year student in the at the Branch of the Russian State Pedagogical University named after A. I. Herzen in Tashkent

Abstract

The paper presents a practice-oriented approach to introducing senior preschool children (6–7 years) to the Möbius strip through mathematical modeling and guided experimentation. Möbius strip activities are described as a low-cost, high-impact pedagogical tool that strengthens children's spatial representations, visual–figurative thinking, attention, and logical reasoning. The proposed methodology is built around problem situations, inquiry-based tasks, and play-based experiments that help children move from direct manipulation to mediated representations (schemes, conditional signs, and modeling actions). The article offers a step-by-step instructional sequence and a set of exploratory tasks that can be used in the educational area "Cognition," as well as in extracurricular mathematics clubs. The approach emphasizes children's autonomy, curiosity, and the development of learning motivation through discovery and reflection.

Keywords

preschool education; mathematical modeling; Möbius strip; inquiry-based learning; problem situation; spatial reasoning; visual thinking; logical reasoning; didactic games; experimentation; observation; reflection

Introduction.

A key objective of developmental education is to create conditions in which a child can choose the direction of intellectual effort, set a goal, and search for a personal way to reach it. In modern preschool education, the educator's role increasingly shifts from transmitting ready-made information to designing learning environments that teach children how to learn: how to observe, pose questions, test ideas, and justify conclusions.

One of the central principles of cognitive development is the systematic stimulation of children's curiosity. For this purpose, learning materials must be meaningful, engaging, and experimentally accessible. The Möbius strip is one such material: it is easy to make from paper, yet it reveals an unexpected geometric property (a one-sided surface), which naturally produces a "surprise effect" and motivates inquiry.

Children tend to learn most actively when they become participants in discovery: they manipulate objects, try alternatives, compare results, and formulate explanations. Therefore, modeling problem-based situations in a play format can function as an effective pathway to developing learning motivation and thinking strategies.

Research problem

How can modeling of problem-practical situations, supported by simple experiments with the Möbius strip, strengthen learning motivation and conceptual thinking in senior preschoolers?

Aim

To develop and describe a methodology for integrating Möbius strip–based experimental modeling into the educational field "Cognition" for children aged 6–7.

Hypothesis

If children are introduced to a mathematical concept through a meaningful problem situation and exploratory activity, they will demonstrate stronger engagement, better reasoning, and deeper conceptual understanding.

Novelty and practical significance

The proposed sequence is designed for senior preschoolers as an advanced-level educational activity and can be recommended for mathematics circles and enrichment programs. It is economical, dynamic (can be implemented in 1–2 sessions), and methodologically flexible.

Main Content

1. Mathematical modeling in preschool education: a practical interpretation

Within preschool pedagogy, mathematical modeling can be understood as a teacher-organized, heuristically oriented process in which children build and transform models using simple planar and spatial representations. This process supports the transition from direct actions with objects to mediated forms of thinking: schematic representation, conditional symbols, and controlled reasoning.

In contemporary early mathematics, modeling tasks should remain developmentally appropriate: they need to preserve play-based motivation while supporting conceptual growth (classification, part–whole relations, spatial orientation, and logical inference).

2. The Möbius strip as a modeling object

A Möbius strip is obtained by taking a paper strip, giving one end a half-turn (180°), and joining the ends. The resulting surface has a non-intuitive property: it can be explored as "one-sided" in the sense that a continuous path can cover what appears to be both "sides" of the original strip without crossing an edge.

Senior preschoolers typically already recognize common plane and solid shapes and can discuss "inside/outside surfaces" of familiar objects. Under teacher guidance, they can construct a Möbius strip and, more importantly, understand its unusual property through carefully designed experiments.

Instructional Sequence: Möbius Strip Modeling in Five Stages

Stage 1. Problem formulation (creating a cognitive challenge)

Teacher prompt: “Do all surfaces have two sides? Can there be a surface with only one side?”

To make the question meaningful, the teacher introduces a short story problem (e.g., two tiny characters that want to meet without crossing an edge). The goal is not to provide the answer, but to establish a need for exploration.

Expected outcome: Children name examples of ordinary two-sided surfaces and begin to search for an exception.

Stage 2. Reproductive modeling (constructing the models)

Children receive: glue, a brush, and two identical paper strips with a dotted midline.

1. Model A (ordinary ring): glue ends without twisting.
2. Model B (Möbius strip): twist one end by 180° and glue.

The teacher repeatedly names the new object and supports accurate construction.

Expected outcome: Children produce two comparable models for later investigation.

Stage 3. Research game (testing hypotheses through play)

The teacher proposes two mini-games:

Game 1: “Travel along the line”

Children mark a point on the dotted line and trace it continuously.

- On the ordinary ring, tracing the line stays on one “side” of the surface.
- On the Möbius strip, tracing the midline returns to the start having passed through what looks like both sides.

Game 2: “Write a letter without lifting the pencil”

Children draw a continuous line, avoiding the edge.

- With the ordinary ring, the line cannot cover both “sides.”
- With the Möbius strip, a single continuous line can “reach everywhere.”

Expected outcome: Children observe and describe the surprising difference, supported by teacher questioning.

Stage 4. Heuristic modeling (predicting outcomes of transformations)

The teacher asks children to predict what will happen if the objects are cut along the dotted midline.

- Ordinary ring: cutting produces two separate narrower rings/strips.
- Möbius strip: cutting produces one longer loop with additional twists (not two separate Möbius strips).

The teacher performs the cut (or children cut with supervision), and the class explains why the result differs.

Expected outcome: Children practice prediction, verification, and explanation.

Stage 5. Extended exploratory tasks (optional enrichment)

If children remain motivated, the teacher offers additional tasks:

1. Second cut experiment: Cut the resulting loop again along its midline; describe and compare the outcomes.

2. “Paper traveler” task: Attach a small paper “soldier” to a path and observe how its orientation changes during travel.
3. Applied engineering challenge (age-appropriate wording): “How could we make a belt last longer if one side wears out faster?”
(Teacher leads children to the idea that a twisted belt distributes wear more evenly.)

Expected outcome: Children generalize the concept and connect it to real-life design thinking.

Discussion.

Möbius strip activities support several interconnected educational outcomes:

1. Spatial and topological intuition: Children encounter a non-standard surface property and learn that geometry includes more than familiar plane/solid forms.
2. Model-based reasoning: Children operate with a constructed model, compare cases (ordinary ring vs Möbius strip), and draw conclusions from experiments.
3. Motivation through problem situations: The “mystery” of a one-sided surface naturally activates curiosity and sustained engagement.
4. Early research culture: Observation, hypothesis, verification, and reflection become child-friendly habits when embedded in play and dialogue.
5. Development of logical speech: Children are encouraged to justify (“because…”, “if… then…”, “I think… because…”), which strengthens reasoning.

From a methodological standpoint, the approach aligns with modern requirements of preschool education: the content remains accessible, yet it cultivates higher-order thinking through inquiry and modeling.

Conclusion.

Möbius strip–based modeling is an effective and resource-efficient method for enriching mathematical development in senior preschool age. The proposed five-stage methodology demonstrates how a simple paper object can become a powerful tool for cultivating curiosity, spatial reasoning, logical inference, and reflective thinking. Importantly, the approach supports child autonomy and teacher creativity while preserving the humanistic principle of learning through play and meaningful exploration. Möbius strip activities can be successfully implemented in regular classes and in enrichment formats such as mathematics clubs.

REFERENCES

1. Pickover, Clifford A.. *The Möbius Strip: Dr. August Möbius's Marvelous Band in Mathematics, Games, Literature, Art, Technology, and Cosmology.* — New York: Basic Books, 2006.
2. Gardner, Martin. *Mathematical Puzzles and Diversions.* — New York: Simon and Schuster, 1959.
3. Weeks, Jeffrey R.. *The Shape of Space: How to Visualize Surfaces and Three-Dimensional Manifolds.* — New York: Marcel Dekker, 1985.
4. Piaget, Jean. *The Origins of Intelligence in Children.* — New York: International Universities Press, 1952.
5. Vygotsky, Lev S.. *Мышление и речь.* — М.: Лабиринт, 1999.
6. Elkonin, Daniil B.. *Психология игры.* — М.: Педагогика, 1978.
7. Galperin, Pyotr Ya.. *Введение в психологию.* — М.: Изд-во МГУ, 1976.
8. Wenger, Leonid A. (ред.). *Развитие познавательных способностей в процессе дошкольного воспитания: коллективная монография.* — М.: Педагогика, 1986. — 224 с.
9. Poddiakov, Alexander N.. *Исследовательское поведение: стратегии познания, помощь, противодействие, конфликт.* — М.: ПЕР СЭ-Пресс, 2006.
10. Leushina, Antonina M.. *Формирование элементарных математических представлений у детей дошкольного возраста.* — М.: Просвещение, 1974. — 368 с.
11. *Формирование элементарных математических представлений у дошкольников* / под ред. А. А. Столяра. — М.: Просвещение, 1988.
12. Beloshistaya, Anna V.. *Формирование и развитие математических способностей дошкольников: вопросы теории и практики: курс лекций.* — М.: ВЛАДОС, 2003. — 400 с.
13. Mikhaylova, Zinaida A.. *Игровые занимательные задачи для дошкольников.* — СПб.: Детство-Пресс, 1990.
14. Mikhaylova, Zinaida A., Бабаева Т. И. *Развитие познавательных и исследовательских умений у старших дошкольников: методическое пособие для педагогов.* — СПб.: Детство-Пресс, 2012.
15. Shcherbakova, E. I.. *Методика обучения математике в детском саду.* — М., 2000.