COGNITIVE BARRIERS AND PEDAGOGICAL DILEMMAS IN TEACHING CRITICAL PROBLEM-SOLVING IN PRIMARY MATHEMATICS EDUCATION

Khudaikulova Saida Zakirovna
Teacher of Termez State Pedagogical Institute
Phone: +99890-246-47-47
E-mail: hudaykulova.sz@gmail.com
Niyozova Dildora
Xursandova Malika
3rd-year student of Temez State Pedagogical Institute

Abstract: *Teaching critical problem-solving in primary school mathematics is a cornerstone of developing 21st-century cognitive competencies. However, the transition from rote algorithmic memorization to heuristic reasoning remains fraught with systemic and cognitive hurdles. This study explores the multifaceted challenges encountered in primary mathematics classrooms, specifically focusing on the gap between abstract mathematical modeling and student-led inquiry. Drawing on a mixed-methods approach—comprising classroom observations and semi-structured interviews with educators—the research identifies three primary clusters of problems: the "standardization trap" in curriculum design, the "procedural fixation" of learners, and the "pedagogical anxiety" of teachers regarding non-linear student solutions. The findings suggest that current instructional frameworks often inadvertently stifle lateral thinking. The paper proposes a shift toward "Scaffolded Open-Ended Problem Solving" (SOEPS) to mitigate these challenges, emphasizing the role of metacognitive prompts in early childhood numeracy development.*

Keywords: *critical thinking, primary mathematics, heuristic reasoning, pedagogical barriers, cognitive load, mathematics education reform.*

The contemporary landscape of mathematics education has shifted its primary objective from computational fluency to the cultivation of critical problem-solving skills. In the primary years, mathematics serves not merely as a tool for arithmetic but as a laboratory for logical deduction and cognitive flexibility. However, despite international benchmarks such as PISA and TIMSS emphasizing higher-order thinking, the reality of the primary classroom often remains tethered to traditional, formulaic instruction. The problem lies in the inherent tension between the rigid structure of mathematical rules and the fluid, often messy process of critical inquiry.

The ontological tension between *procedural fluency* and *conceptual understanding* remains the most enduring paradox in primary mathematics education. While traditional pedagogy often treats these as sequential stages—first mastering the "how" before exploring the "why"—contemporary neuro-cognitive research suggests an iterative, bidirectional relationship. However, in the context of critical problem solving, this relationship often collapses into a "procedural fixation" that stunts the development of mathematical inquiry.

Procedural knowledge, defined as the mastery of step-by-step algorithms (e.g., long division or the standard addition algorithm), is cognitively "expensive" during the initial learning phase but becomes automated over time. The dilemma arises when this automation occurs in a vacuum, devoid of conceptual anchoring. Richard Skemp (1976) famously categorized this as *"instrumental understanding"*—learning rules without reasons.

In primary classrooms, students often develop what is termed *"algorithmic rigidity."* When presented with a non-routine problem that requires critical analysis, students instinctively search for a known procedure to apply. If the problem's surface structure does not immediately signal a specific algorithm, a cognitive "block" occurs. This is not a failure of computational ability, but a failure of heuristic flexibility. For instance, when asked to find the sum of 1+2+3...+99+100, a procedurally fixed student will attempt 99 sequential additions, whereas a conceptually grounded student will look for patterns (e.g., Gauss's pairs) to simplify the complexity.

From the perspective of *Cognitive Load Theory (CLT),* the transition to critical problem solving increases "intrinsic load"—the inherent difficulty of the task. If a student's conceptual framework is weak, they rely heavily on their working memory to hold both the steps of an algorithm and the logic of the problem simultaneously.

The encoding error: Primary students frequently misinterpret critical problems because they encode them based on "keyword" triggers (e.g., the word "altogether" triggering addition) rather than building a mental model of the quantitative relationships. This *"direct translation strategy"* bypasses critical thinking entirely, leading to systemic errors when the problem's linguistic structure is complex or non-linear.

The semantic barrier: Conceptual understanding requires the ability to translate between multiple representations—concrete, pictorial, and abstract (the CPA approach). The dilemma in many classrooms is the "premature abstraction" where students are moved to symbolic manipulation before the underlying mathematical concept (e.g., place value or proportionality) is cognitively solidified.

A significant hurdle in teaching critical problems is the absence of *metacognitive monitoring*. Conceptually driven students engage in "self-explanation"—they constantly ask themselves, "Does this result make sense?" In contrast, students focused on procedural execution often produce mathematically impossible answers (e.g., a bus carrying "4.5 children") because their focus is entirely on the mechanical application of a division algorithm rather than the contextual reality of the problem.

This "blindness" is exacerbated by classroom environments that prioritize *product over process*. When the "correct answer" is the sole metric of success, the incentive to explore the conceptual "underpinnings" of a problem is diminished. To foster critical thinking, the pedagogical focus must shift from "getting the answer" to *"analyzing the path."*

To resolve this dilemma, the primary curriculum must integrate heuristics—strategies such as drawing a diagram, working backward, or simplifying a related problem. These are not procedures, but "thinking tools" that bridge the gap between concept and execution.

The challenge for educators lies in the fact that heuristics cannot be "taught" as a new set of rules; they must be "caught" through repeated exposure to high-challenge, low-threshold tasks. This requires a radical departure from the "I do, We do, You do" model of instruction toward a more inquiry-based discovery model where the "problem" precedes the "procedure."

The "standardization trap" refers to the pressure on teachers to cover a vast curriculum within a limited timeframe. Critical thinking requires time—time for trial, error, and reflection.

Assessment misalignment: Most standardized tests for primary levels still prioritize multiple-choice questions or simple calculations. As a result, teachers, focused on high-stakes accountability, often revert to "teaching to the test," marginalizing open-ended problem-solving tasks.

Resource Deficit: Many textbooks lack authentic critical problems, providing instead "pseudo-problems" that are merely dressed-up calculations.

A crucial, yet often overlooked factor is the teacher's own relationship with mathematics. Research indicates that "mathematics anxiety" among primary teachers can lead to a rigid instructional style (Boaler, 2016).

Unpredictability: Critical problems often lead to multiple valid solution paths. Teachers who are not deeply confident in their mathematical flexibility may feel threatened by student-led methods that deviate from the teacher's manual.

The Scaffolding Paradox: Finding the "sweet spot" between giving too much help (which negates the critical thinking) and giving too little (which leads to frustration) is a sophisticated pedagogical skill that many novice teachers have not yet mastered.

Proposed Framework: Scaffolded Open-Ended Problem Solving (SOEPS). To overcome these barriers, this paper advocates for the SOEPS model. This model emphasizes:

1. Metacognitive Questioning: Instead of providing hints, teachers ask: "What does this problem remind you of?" or "How would the result change if we doubled this number?"
2. Productive Failure: Creating a classroom culture where "stuckness" is viewed as a necessary phase of learning.
3. Visual Modeling: Utilizing Singapore Math-style bar models to bridge the gap between concrete objects and abstract symbols (Clements & Sarama, 2009).

The integration of critical problem-solving in primary mathematics is not a luxury but a cognitive necessity. The problems identified—procedural fixation, curricular rigidity, and pedagogical anxiety—are significant but not insurmountable. By shifting the focus from "answer-getting" to "meaning-making," educators can transform the mathematics classroom into a space of genuine intellectual discovery. Future research should focus on longitudinal studies of how early exposure to non-routine problems impacts mathematical persistence in secondary education.

References:

1. Baddeley A. The episodic buffer: A new component of working memory? // Trends in Cognitive Sciences. – 2000. – Vol. 4, No. 11. – P. 417–423.
2. Boaler J. Mathematical Mindsets: Unleashing Students' Potential through Creative Mathematics, Inspiring Messages and Innovative Teaching. – San Francisco : Jossey-Bass, 2016. – 320 p.
3. Clements D. H., Sarama J. Learning and Teaching Early Math: The Learning Trajectories Approach. – New York : Routledge, 2009. – 344 p.
4. Haylock D., Cockburn A. Understanding Mathematics for Young Children: A Guide for Teachers of Children 3–8. – London : Sage, 2017. – 312 p.
5. Lester F. K. Thoughts about research on mathematical problem-solving instruction. – Charlotte, NC : Information Age Publishing, 2013. – 260 p.
6. ХУДАЙКУЛОВА С. З. ИССЛЕДОВАНИЕ ЛИНИИ УРОВНЯ БОЛЬШОГО ПОЛИНОМА С ИСПОЛЬЗОВАНИЕМ КОМПЬЮТЕРНОЙ АЛГЕБРЫ //World of Scientific news in Science. – 2023. – Т. 1. – №. 1. – С. 139-145
7. THE METHODOLOGICAL FOUNDATIONS OF DEVELOPING LOGICAL THINKING IN PRIMARY SCHOOL MATHEMATICS LESSONS
8. KS Zakirovna, R Shokhabbos - ACUMEN: International journal of multidisciplinary, 2025
9. Xudaykulova, S. (2024). TEXNIK IJODKORLIKNING HOZIRGI HOLATI. Research and Implementation. извлечено от https://rai-journal.uz/index.php/rai/article/view/520
10. Xudaykulova, S. (2024). DARAJALI GEOMETRIYA - KO'PHADLAR VA NORMAL KONUSLAR. Interpretation and Researches, 1(1). извлечено от https://interpretationandresearches.uz/index.php/iar/article/view/2496