

Developing Mental Calculation Competency in Primary School Students: Problems and Pedagogical Approaches

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Abstract: This article highlights the theoretical foundations and existing practical challenges of developing mental calculation competency among primary school students. It critically analyzes the difficulties caused by traditional calculation patterns and substantiates the implementation of flexible mental strategies in their place. Furthermore, pedagogical recommendations are proposed for fostering students' skills in performing arithmetic operations fluently, rapidly, and consciously through the development of number sense and working memory.

Keywords: Mental computation, primary education, standard algorithms, number sense, decomposition, mental strategies, competency.

Introduction: Developing mental calculation competency in primary education is not merely a matter of memorizing arithmetic rules; it serves as a foundational factor in fostering logical thinking, "number sense," and intellectual flexibility in children. For many years, traditional methodology viewed oral calculation within a narrow scope-such as rapidly reciting multiplication tables or adding single-digit numbers mentally. However, modern pedagogy confirms that it is a comprehensive cognitive process that enhances working memory [1].

Nevertheless, in current school practice, students are excessively bound to rigid standard algorithms, namely column-based calculations and long division rules. These traditional patterns impede the understanding of place value and the real essence of numbers, forcing children to execute a sequence of mechanical steps without deep comprehension. Consequently, students develop anxiety toward arithmetic operations, retaining a reliance on artificial supports-such as drawing tally marks in the margins or counting on fingers-even in higher grades when performing complex tasks [2]. Furthermore, educational curricula often address oral calculation briefly at the beginning of the academic year

without integrating it into subsequent topics, while teachers themselves often lack sufficient awareness of non-standard mental calculation methods, further deepening the problem.

The root cause of this systemic crisis lies in what educational theory terms "banking education," where students' minds are viewed as empty containers and the teacher as a subject who pours ready-made rules into them. Precisely for this reason, students in traditional classrooms do not independently analyze numbers; instead, they merely execute formulas. Conversely, the theory of constructivism posits that humans do not passively receive mental knowledge in a finalized form, but rather construct it through personal activity and internal cognitive inquiry [3]. From this perspective, mental arithmetic is not merely a textbook topic, but a primary pedagogical tool that unleashes a child's independent cognitive activity. A genuine culture of mental computation must consist of two essential components: first, the rapid retrieval of basic numerical facts; second, the capacity to mentally construct new and complex calculation strategies. Unfortunately, current practice often focuses exclusively on the first component, limiting instruction to rote memorization.

In reality, in today's information-driven society, a person can verify large-scale operations with a calculator, but relies on their internal "number sense" to monitor whether the calculation is heading in the right direction, comprehend its logical basis, and estimate the approximate result [4]. If this sense is not developed in primary grades, severe cognitive barriers will inevitably arise when mastering higher-level STEM disciplines that require algebraic and functional reasoning.

To overcome these pedagogical barriers and fully develop mental calculation competency in students, a series of non-standard arithmetic strategies must be systematically introduced into the instructional process. In this regard, flexibly decomposing numbers by place value and calculating from left to right-which is more natural for the human brain than traditional right-to-left computation-allows students to immediately perceive the overall scale of the result. Additionally, the "compensation" strategy (converting a number into a convenient benchmark number such as 10, 100, or 1000 and adjusting the difference at the end) and the "constant difference" strategy (adding or subtracting the same value from both numbers to simplify subtraction) completely free children from difficulties such as excessive "borrowing" or confusing intermediate results [5]. In multiplication, utilizing the distributive property strengthens the skill of mentally solving complex operations by breaking them into manageable parts. Integrating these methods into lessons provides students with the opportunity to break free from rigid patterns, freely select the most convenient strategy according to the situation, and execute it mentally.

From a practical standpoint, implementing this approach in general education schools requires organizing brief, 3-5 minute "intellectual sprints" at the beginning of every mathematics lesson-focused entirely on mental analysis without notebooks-fostering an environment where students do not fear making mistakes, and building a culture of using calculators strictly as self-assessment tools. Furthermore, introducing modules on teaching non-standard arithmetic strategies into professional development courses for educators will ensure the continuity of this system.

The practical effectiveness of these non-standard

methods is further demonstrated by their deep application beyond whole numbers to the most complex areas of primary education: fractions, decimals, units of measurement, and percentages. For example, students often mechanically memorize rigid standard rules when multiplying or dividing proper and decimal fractions without understanding the underlying meaning. However, if students are taught to mentally simplify dividends and divisors using common factors, convert numbers into convenient decimal forms, or apply the distributive property to fractional expressions, multi-step operations are transformed into simple, effortless actions within seconds. Moreover, mental calculation competency is intrinsically linked to the skill of "computational estimation". Estimating a result requires three main cognitive steps: transforming data into a manageable form, simplifying the problem's structure, and mentally correcting the resulting error. These cognitive operations build functional mathematical literacy-enabling children to apply mathematics in daily life, such as shopping in a store, measuring time and distance, or allocating a budget, rather than merely manipulating numbers on paper. Only when children connect operations on numbers to their real lives does mathematics cease to be an abstract and boring subject, becoming instead a living tool for understanding the environment and solving real-world problems.

At the same time, proper development of mental calculation competency relies directly on the teacher's questioning culture and pedagogical communication style in the classroom. Classroom observations indicate that in traditional education, when a student gives an incorrect answer, the teacher rarely asks for the underlying reason or analyzes the mistake, opting instead to write the correct answer on the board. This authoritarian approach extinguishes the child's desire to express their thoughts freely, explain their calculation process, and search for alternative pathways. In mental arithmetic lessons, the focus must shift from the final result to uncovering the child's cognitive chain through questions such as "How did you arrive at this result?" or "Is there a more convenient way?" [6]. Only when students articulate their mental operations verbally do concepts become consciously reinforced, elevating their mathematical reasoning skills to a higher level. Furthermore, creating an atmosphere

of collaborative discussion and comparative analysis of non-standard methods gives every child the freedom to find a strategy tailored to their cognitive capabilities. This frees primary school students from artificial constraints, directly serving to nurture them into independent thinkers with high self-confidence.

The psychological and neurobiological mechanisms of developing mental calculation competency also warrant a deeper examination. Modern cognitive research demonstrates that oral calculation maximally activates human working memory and executive functions [7]. In traditional column-based computation, because students record intermediate data on paper, the cognitive load placed on working memory remains minimal. In contrast, mental arithmetic requires a child to simultaneously execute multiple cognitive operations: retaining intermediate results in memory, processing new operations, and adaptively shifting strategies. This process demands seamless coordination between the "central executive" and the "visuospatial sketchpad" within Baddeley's working memory model [8]. From a neuropedagogical perspective, since neural plasticity in primary school-aged children is exceptionally high, mental calculation exercises during this period strengthen interhemispheric connections and neural networks in the brain. Furthermore, through the integration of visual memory and motor perception, children construct quantitative and spatially modeled representations of numbers rather than viewing them merely as abstract symbols. This, in turn, enhances the student's overall intellectual capacity and significantly accelerates their speed of logical analysis. Consequently, fostering mental computation is not merely an endpoint of mathematics education, but a crucial catalyst driving overall cognitive development.

CONCLUSION

In conclusion, by moving away from the rigid boundaries of standard algorithms and teaching flexible mental calculation methods from the primary grades onward, we enhance students' calculation speed and accuracy while simultaneously fostering their independent, creative, and analytical thinking.

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