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A mathematical problem that just doesn't add up

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Most of us share it and it seems a safe enough assumption: mathematical skills and performance develop and advance as students progress through their elementary school years. However, a new study by University of Notre Dame psychologist Nicole M. McNeil suggests that for at least one type of math problem, 7-year-old students are outperforming 9-year-olds.

McNeil analyzed how 7- to 11-year-old children performed on "equivalence" problems. An example of an equivalence problem is: "3+4+5= 3+_." Previous studies have shown that children have substantial difficulties with mathematical equivalence problems. For example, many come up with solutions for the right side of the equation that range from "3+12" to "3+15." (For the numerically challenged, the answer is 9.)

"Mathematical equivalence is a fundamental concept in algebra and success in algebra is crucial to future educational and employment opportunities," McNeil said.

No previous study has specifically examined how equivalence performance develops over the course of elementary school years. However, theories that have focused more generally on the development of students' quantitative skills assume that children's difficulties with mathematics are due to something the children lack, such as advanced logical structures, a mature working memory system or proficiency with basic arithmetic facts.

“According to this view, children perform poorly on equivalence problems because they lack the cognitive structures or functions necessary for solving problems correctly, and performance should improve over childhood as those structures or functions develop,” McNeil said.

By contrast, McNeil’s study suggests that children’s difficulties are due, at least in part, to something that they have — existing knowledge. And this existing knowledge promotes “change-resistance” behaviors in students.

“As children learn arithmetic between the ages of 7 and 9, they pick up on at least three, recurrent arithmetic-specific patterns,” McNeil said. “First, they learn that the equal sign and answer blank come together at the end of the problem (3+4=_). Second, children learn to interpret the equal sign as an operator (like + or -) that means ‘calculate the total.’ And thirdly, children learn to solve math problems by performing all given operations on all given numbers.”

Although these patterns likely help performance on traditional arithmetic problems (3+4=_), they do not help, and most likely hinder, performance with equivalence problems, which do not adhere to the traditional form.

“To solve an equivalence problem correctly, children must notice that the equal sign is not at the end of the problem, understand that the equal sign denotes an equivalence relation between the two sides of the equation, and manipulate the numbers and operations to arrive at an answer that makes both sides of an equation have the same value,” McNeil said. “To satisfy these conditions, children must either ignore or override their long-term memory of the operational patterns.”

McNeil conducted two separate studies of 7- to 11-year-olds in

Pittsburgh and Raleigh, N.C., schools, respectively, that confirmed that performance on equivalence problems declined between age 7 and 9 before improving between the ages of 9 and 11.

“These findings challenge our intuition and several prevailing theories, but they support change-resistance accounts,” McNeil said.

McNeil points out that similar results have been found for Canadian children, but interestingly enough, not for those in China.

“In the United States, children’s early mathematics experience is heavily weighted toward arithmetic operations such as addition, subtraction, multiplication and division,” McNeil said. “Children learn arithmetic in a very procedural fashion for many years before they learn to reason about equations as expressions of mathematical equivalence.”

McNeil’s research paper appears in the May edition of the American Psychological Association journal *Developmental Psychology*.

Source: University of Notre Dame

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