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Report # 118

Closing The Gap In Mathematical Knowledge

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The Troubling Gap in Math Knowledge

Closing The Math Gap

Activities as simple as board games help

Surprisingly, helping young low-income children overcoming deficits in math and improve their overall mathematical knowledge could be as simple as playing a very basic board game, not unlike the popular Chutes and Ladders.

Recent studies suggest that such activities promote the development of number sense, a key mathematical ability related to understanding numerical magnitudes that many young children – particularly those from low-income families – have trouble mastering. And improving such skills is seen as a step toward narrowing the gap in mathematical knowledge that results in low-income children starting school well behind their more affluent peers.

This gap, which is seen across fundamental math tasks ranging from counting from one to comparing the magnitudes of numbers, begins to develop years before children enter school. Studies have found that deficits in math knowledge in kindergarten tend to predict children's scores on achievement tests during the elementary grades and into high school.¹ In general, children who fall behind early, stay behind.

One reason for the knowledge gap appears to be differences in support children receive for learning. Those children whose parents engage them in simple math-related activities tend to develop a better understanding of math concepts. In studies, low-income parents have been found to be less likely to adopt such activities as part of the parenting practices.²

Developing Number Sense

Researchers looking to prevent early math deficits and close the

knowledge gap are focusing on simple activities that promote the development of important concepts and that can be readily used with low-income children at home, in childcare and in preschool classrooms.

One area of interest is in helping young children develop number sense, an area of mathematical knowledge found to be particularly weak among low-income children. Carnegie Mellon University researcher Robert Siegler and colleagues have investigated ways to help young children better develop this important math ability.

For the purpose of the study, they defined number sense as the ability to approximate numerical magnitudes.³ Such approximations can be applied to numerical operations, such as answering the question: "About how much is 12×55 ?" Another use is in approximating objects, events or sets. For example, "How many people were at the football game?"

Children's mathematical knowledge begins to form very early in life, long before they enter school. Unfortunately, so do the deficits in basic mathematics that result in many low-income starting school behind their more affluent peers.

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To investigate children's number sense, they relied on estimation tasks using a number line. Studies suggest math achievement correlates with children's ability to correctly space numbers on number lines – an ability young children find difficult, but which improves with age and experience. For example, even preschoolers who can count perfectly from 1 to 10 do not understand the rank order of the numbers' magnitude.⁴

Counting Experiences

Counting is one of the early childhood experiences researchers believe lead children to represent the magnitudes of small, verbally stated or written numerals as increasing linearly.

One activity considered well suited to producing such representations is playing board games with linearly arranged, consecutively numbered, equal-size spaces – Chutes and Ladders, for example. The popular

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children's game includes a board with numbers up to 10, each of which occupies a square of equal size, with the squares arranged in a grid.

Games such as Chutes and Ladders give children cues to the order and the magnitude of numbers. The greater the number in a square, for example, the greater number of moves the child makes with the token or the greater distance the token travels. The game also allows a child to practice counting and identifying numerals.

The researchers designed their own simple board game and investigated its effectiveness in promoting number sense among 4- and 5-year-olds enrolled in Head Start programs. To test the game, they randomly assigned the children to play one of two versions.

Each version of the game had 10 squares of equal size horizontally arranged. But one game had the numbers 1-10 listed consecutively from left to right, while the other game had colored squares without numbers. Children spin a spinner and move a token the number of spaces that are shown on the spinner. For the study, they were also asked to say the numbers or colors on the spaces they moved the token through.

They were also given a number line estimation task with numbers 1-10 before and after they played the game. For comparison, the same task was given to a group of middle-income children who did not play either version of the board game.

The idea behind the number line task was to measure changes in the estimating abilities of the children who played the board game and to compare their performance to that of middle-income children, who studies suggest are exposed to more math-related activities at home.

One promising area of study among researchers looking to close the math gap is in helping young children develop number sense, an area of mathematical knowledge found to be particularly weak among low-income children

Game Shows Promise

Playing the numbered game for even a brief time – eight 15-minute sessions over two weeks – resulted in significant gains in how Head Start children performed on the number line estimation task.

Before children played the numbered board game, the best-fitting linear function on the number line estimation task accounted for an average of only 15% of the variance in individual children's scores. But children improved after playing the game, with the best-fitting linear function on the number line task accounting for an average of 61% of the variance.

In addition, their performance on the number line estimation task rose to levels seen among the middle-income children who had not played the game, but as a group tended to be much more experienced with such board games and other math activities.

The numbered version of the game appears to be the key. Playing the board game that used color squares did not affect the number line estimation performance of the Head Start children who were assigned to it. And they did poorly in their linear function measurement compared to those who played the numbered board game.

A later study reported similar results. Head Start children who were assigned to play the numbered board game showed gains that lasted over a nine-week follow-up period.

Such findings add to a growing body of evidence that suggests improving the numerical understanding of low-income preschool-age children leads to broad, rapid learning. In this case, the learning tool was a simple, inexpensive board game that could be widely used to help close the mathematical knowledge gap between low-income children and their more affluent peers.

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This report is largely based on the following publications.

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⁴ Ramani, G.B., & Siegler, R.S. (2008). Promoting broad and stable improvements in low-income children's numerical knowledge through playing number board games. *Child Development*, 79, 375-394.

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