Children can be systematic problem-solvers at younger ages than psychologists had thought – new research

Celeste Kidd, Professor of Psychology, University of California, Berkeley

How do kids figure out how to sort things by order?
Celeste Kidd

I'm in a coffee shop when a young child dumps out his mother's bag in search of fruit snacks. The contents spill onto the table, bench and floor. It's a chaotic – but functional – solution to the problem.

Children have a penchant for unconventional thinking that, at first glance, can look disordered. This kind of apparently chaotic behavior served as the inspiration for developmental psychologist Jean Piaget's best-known theory: that children construct their knowledge through experience and must pass through four sequential stages, the first two of which lack the ability to use structured logic.

Piaget remains the GOAT of developmental psychology. He fundamentally and forever changed the world's view of children by showing that kids do not enter the world with the same conceptual building blocks as adults, but must construct them through experience. No one before or since has amassed such a catalog of quirky child behaviors that researchers even today can replicate within individual children.

While Piaget was certainly correct in observing that children engage in a host of unusual behaviors, my lab recently uncovered evidence that upends some long-standing assumptions about the limits of children's logical capabilities that originated with his work. Our new paper in the journal Nature Human Behaviour describes how young children are capable of finding systematic solutions to complex problems without any instruction.

Putting things in order

Throughout the 1960s, Piaget observed that young children rely on clunky trial-and-error methods rather than systematic strategies when attempting to order objects according to some continuous quantitative dimension, like length. For instance, a 4-year-old child asked to organize sticks from shortest to longest will move them around randomly and usually not achieve the desired final order.

Psychologists have interpreted young children's inefficient behavior in this kind of ordering task – what we call a seriation task – as an indicator that kids can't use systematic strategies in problem-solving until at least age 7.

Somewhat counterintuitively, my colleagues and I found that increasing the difficulty and cognitive demands of the seriation task actually prompted young children to discover and use algorithmic solutions to solve it.

Piaget's classic study asked children to put some visible items like wooden sticks in order by height. Huiwen Alex Yang, a psychology Ph.D. candidate who works on computational models of learning in my lab, cranked up the difficulty for our version of the task. With advice from our collaborator Bill Thompson, Yang designed a computer game that required children to use feedback clues to infer the height order of items hidden behind a wall, .

The game asked children to order bunnylike creatures from shortest to tallest by clicking on their sneakers to swap their places. The creatures only changed places if they were in the wrong order; otherwise they stayed put. Because they could only see the bunnies' shoes and not their heights, children had to rely on logical inference rather than direct observation to solve the task. Yang tested 123 children between the ages of 4 and 10.

Figuring out a strategy

We found that children independently discovered and applied at least two well-known sorting algorithms. These strategies – called selection sort and shaker sort – are typically studied in computer science.

More than half the children we tested demonstrated evidence of structured algorithmic thinking, and at ages as young as 4 years old. While older kids were more likely to use algorithmic strategies, our finding contrasts with Piaget's belief that children were incapable of this kind of systematic strategizing before 7 years of age. He thought kids needed to reach what he called the concrete operational stage of development first.

Our results suggest that children are actually capable of spontaneous logical strategy discovery much earlier when circumstances require it. In our task, a trial-and-error strategy could not work because the objects to be ordered were not directly observable; children could not rely on perceptual feedback.

Explaining our results requires a more nuanced interpretation of Piaget's original data. While children may still favor apparently less logical solutions to problems during the first two Piagetian stages, it's not because they are incapable of doing otherwise if the situation requires it.

A systematic approach to life

Algorithmic thinking is crucial not only in high-level math classes, but also in everyday life. Imagine that you need to bake two dozen cookies, but your go-to recipe yields only one. You could go through all the steps of making the recipe twice, washing the bowl in between, but you'd never do that because you know that would be inefficient. Instead, you'd double the ingredients and perform each step only once. Algorithmic thinking allows you to identify a systematic way of approaching the need for twice as many cookies that improves the efficiency of your baking.

Algorithmic thinking is an important capacity that's useful to children as they learn to move and operate in the world – and we now know they have access to these abilities far earlier than psychologists had believed.

That children can engage with algorithmic thinking before formal instruction has important implications for STEM – science, technology, engineering and math – education. Caregivers and educators now need to reconsider when and how they give children the opportunity to tackle more abstract problems and concepts. Knowing that children's minds are ready for structured problems as early as preschool means we can nurture these abilities earlier in support of stronger math and computational skills.

And have some patience next time you encounter children interacting with the world in ways that are perhaps not super convenient. As you pick up your belongings from a café floor, remember that it's all part of how children construct their knowledge. Those seemingly chaotic kids are on their way to more obviously logical behavior soon.

Celeste Kidd receives funding from the National Science Foundation, the John Templeton Foundation, the Jacobs Foundation, and the Advanced Research and Invention Agency.