

Students Learn More From Inquiry-Based Teaching, International Study Finds

Experiment had 17,000 students in 4 countries

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Introducing math and science through inquiry and problem-based instruction can pay off throughout elementary school, according to a massive international series of studies.



Education economists Emma Näslund-Hadley and Rosangela Bando, of the Inter-American Development Bank, and Paul Gertler of the University of California, Berkeley, conducted 10 randomized controlled experiments with more than 17,000 students in Argentina, Belize, Paraguay, and Peru, four countries working with the Inter-American Development Bank to implement inquiry-based math and science programs.

The researchers randomly assigned preschool, 3rd, and 4th grade classes to use either inquiry-based instruction or the standard math and science instruction in their schools—which generally involved teacher lectures, memorization, and practice. (While students in most countries were assigned by class, in Peru students were taught in small groups of four to seven students, and so they were assigned individually.)

The studies were laid out last week in a working paper of the National Bureau of Economic Research. The findings come as more schools in the United States and throughout the Americas explore problem- and inquiry-based programs, particularly in science and math. These are the largest-scale randomized trials on the approach, and the first to look at preschool students as well as those in elementary grades.

Difference in Practice

A typical lesson looked very different in the standard and inquiry-based classes.

"When kids did hands-on experiments in [a standard] science class, the teacher was doing the experiment in front of the class—no opportunity for hands-on learning," Näslund-Hadley said.

In a unit on ratios in Belize, for example, a teacher in a typical math class would explain the definition of a ratio and demonstrate basic problems; students then spent the rest of the period practicing problems, before being quizzed.

In the inquiry class, by contrast, the teacher compared the number of students wearing short- and long-sleeved shirts and similar examples within the classroom to start students thinking about the concept, then paired off students to come up with their own definitions of what a ratio could be. The class worked through exercises on how ratios might be used in real life, such as using colored rods of different lengths to measure their desks and look at the relationships between the unit length and the number of rods needed to measure. Then the teacher and class discussed their findings and decided on a revised definition of the ratio concept.

Inquiry- or problem-based learning has taken off in recent years in U.S. schools in the wake of **Common Core State Standards** and Next-Generation Science Standards, as well as in schools around the world.

The researchers compared the range of scores on standardized math and science tests in each group before starting to implement the inquiry-based instruction, and then again seven months later. They found that in the classes that used inquiry-

What Is an Inquiry-Based Lesson?

New research suggests students can benefit from inquiry- and problem-based instruction in math and science classes, even in very early grades.

Programs and approaches can vary, but researchers found some common elements:

based instruction at least four days a week for during that time, students improved significantly more in math and science than students in the regular classes. The average student in inquiry classes performed 0.14 of a standard deviation higher than the average student in a standard class in science and 0.18 of a standard deviation higher in math by the end of the school year.

Students across grades and across countries showed similar benefits from the inquiry-based classes, including the preschoolers.

"It's fascinating because when we have discussed the possibility of doing this research with governments in the region, they said, 'Oh, the children must be too young to do anything like this,' " Näslund-Hadley said, "and now they've actually noted that that is possible for younger children to think like a scientist."

"Clearly it is possible to work scientific and mathematical thinking from a very, very early age without making it ... rote memorization," she said.

At that rate of improvement, the researchers estimated the average student in inquiry-based math and science classes for four years would perform nearly two-fifths of a standard deviation better than their peers in math and more than one-fifth of a standard deviation better in science. Standard deviation is the measure of how a given set of test scores vary.

Gender Gaps and Costs

While both boys and girls improved in inquiry-based classes, the researchers found that boys improved faster, widening the gender achievement gap. Overall, boys in inquiry classrooms improved by .22 of a standard deviation over peers in math, compared to girls improving .15 of a standard deviation more than peers in standard classes. The same held in science, with boys improving .18 of a standard deviation, compared to a tenth of a standard deviation for girls.

"That was highly shocking," Näslund-Hadley said. "It's not that girls lost ground from the inquiry; they grew more than boys [in standard classes.] The bump in improved learning was so much greater for the boys.

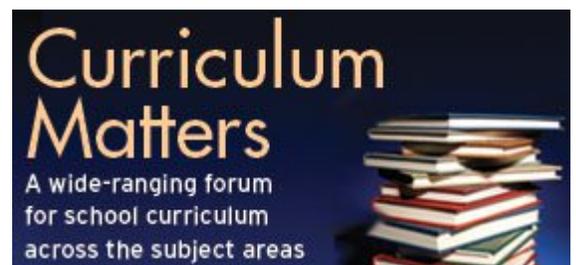
"What we saw with respect to gender was the teachers appear to have implicit gender biases and tend to focus more on the boys in the classroom," she said. In projects that involved more group and class discussions and collaboration, that problem was exacerbated. Näslund-Hadley said the countries have since been working to provide more training before and during implementation to encourage teachers to involve students more equitably.

Still, the studies found inquiry- or problem-based instruction could prove more cost-effective than standard instruction, particularly for improving achievement for low-income students. (Average incomes in the countries range from just over \$4,000 a year in Paraguay to \$12,440 a year in Argentina, in U.S. dollars.)

Using the inquiry-based instruction, the researchers found the cost of increasing math test scores by a tenth of a standard deviation in a year was just over \$18 per student in math and under \$18 per student in science.

- Students are presented with a question or problem that they must work on collaboratively to solve or explain.
- Students learn both to seek outside credible sources and to collect their own data to investigate the problem.
- Students work with others to develop theories and explanations.
- Teachers incorporate explicit instruction and scaffolding at relevant points during the inquiry, connecting the content students have learned and the processes they used to complete the activity to other core concepts and ways students could solve similar problems in the future.

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"It's interesting to observe that it not only works, but works in a variety of contexts. That makes the investment more worthwhile," said Bando of the Inter-American Development Bank. She noted that the bank has since been working with the governments to provide the framework and materials for the curriculums for free.

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