U.S. Struggles To Solve Its Math Problem

Time, Teaching Style Appear to Be Factors

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The eighth-graders at Jackson Middle School in Fairfax County knew what they were in for as soon as they walked into math class. On a screen in front of the room, their teacher, Eugene Pair, had projected six equations next to the words "No Calculators."

The class began with groans and complaints. But Pair was unapologetic. "You guys have been doing this since the fourth grade," he said, "so it should be no problem."

For the next half hour, writing on an overhead projector, Pair showed how to solve the problems. Then he gave the students 20 more equations to tackle in seven minutes. He spoke, they listened. Then they took to the task with pen and paper.

This is the traditional approach to teaching math, an integral part of schools across the nation. It relies on textbooks, repetitive problem-solving and drills to gauge what students know. Like many educators, Pair believes in it. "The structure is good. It works," he said one recent afternoon after class.

But now, those venerable classroom habits are under attack.

A landmark study comparing how American students fare in math to their peers in other industrial nations, such as Germany and Japan, recently directed sharp criticism at schools for what they expect of students, and at teachers for how they instruct them.

Relying on math formulas or drills in class, the study suggests, bores many students and undermines their performance. In many other nations, teachers are putting more emphasis on creative learning exercises that challenge students to discover math concepts on their own -- not just plug numbers into equations.

Since its release late last year, the study has ignited widespread debate about what schools ask of students and teachers in math. President Clinton took up the issue during a visit yesterday to schools in suburban Chicago, where he urged educators to raise math standards and to improve how they teach the subject.

"What our students learned in math in the eighth grade is learned in Japan in the seventh grade," Clinton said. "Even more troubling to me . . . students in Germany and Japan learn 10 to 20 math subjects in depth; our students are asked to cover 35 math subjects and, therefore, don't learn any of them in depth."

As part of the study Clinton referred to, a half-million eighth-graders in 41 countries were tested in math. Researchers also surveyed teachers, analyzed curricula and videotaped class instruction around the world. What they found was distressing.

"American students are taught very quickly how to do things in math," said Eugene Owen, an analyst with the Education Department who helped coordinate the study. "In a country like Japan, there's more emphasis on getting students to understand underlying concepts in math. If an

American student forgets a formula, he tends to be up a creek."

Nationwide, many schools are reexamining their math programs and making changes in style and rigor. For the first time, some are now requiring ninth-graders to take algebra, for example. Nationally, math scores are creeping upward.

Yet the study contends American students still rank below the international average in math, even though they spend more class hours on math and get more homework. That suggests the roots of the problem are deep. Solving it, educators say, will present at least one profoundly difficult task: changing the mindset of teachers.

"If you want teachers to lead children in hands-on learning, teachers have to experience that themselves, and few have," said Richard J. Murnane, an education professor at Harvard University. "Most have been taught with a chalk-and-talk method. Changing that is not easy, especially if the only training you get is a workshop now and then. It takes much more time and perseverance."

experience of Fairfax County is a microcosm of the struggles facing many school systems as they try to teach math, a subject educators and employers often rank second only to language and reading in terms of importance.

Student math scores in Fairfax are higher than those in most other districts. Yet even in this prosperous system, the challenge to change teacher habits is immense.

"Teachers tend to teach the way they were taught, and they were all taught by a teacher giving three examples and saying, `Now you practice,' " said Tom Nuttall, Fairfax's math coordinator. "We're talking about a cultural change here."

The difficulty of achieving that is most apparent in elementary schools, where educators say teachers tend to have the least familiarity with math, and show little inclination to learn more.

Last year, Fairfax offered elementary math teachers two training courses. In the easier session, the emphasis was on teaching "methods." About 600 teachers signed-up. In the other, they had to learn the "content" of what they teach. Six teachers came.

"If you suffer from math anxiety, I don't know how you can teach the subject, other than following the book," Nuttall said. "We still hear stories about teachers who say to students, `If you're good at recess today, you won't have to take math.' "

Fairfax officials began overhauling math instruction four years ago. First, they pared back the material students were expected to learn, to give teachers more time to focus on lessons. One of the faults the study found is that even the best American teachers have to race through work to keep pace with school curricula.

Fairfax teachers were encouraged to be creative by using geometric blocks or other props to illustrate math concepts. Middle school students were urged to take algebra, a subject traditionally reserved for high school, but which other countries teach earlier. In the last five years, the proportion of Fairfax eighth-graders taking algebra has soared from less than one in five to almost half.

But even teachers promoting this revamped approach say having it take root is a constant battle. Consider Deborah Gutman. She helped develop the county's math curriculum and she teaches at Jackson Middle School.

Her students rarely use textbooks. When she assigns equations, she rarely solves them at a blackboard. Instead, she encourages students to analyze problems with brightly colored blocks that represent abstract equations. Then she asks them to defend their solutions. The problem: It takes time. Gutman does not have much of it.

One recent afternoon, she wanted to teach the concept of proportional reasoning. Rather than work through a series of equations, she asked the 12-year-olds to imagine baking batches of chocolate chip cookies. She held up cartons of sugar, flour and butter and asked them to calculate the lowest possible cost per dozen.

Students were intrigued. But by the time they had tried a few practice problems and divided into groups, there were only 12 minutes left in the 47-minute class. Gutman dashed around the class to encourage the experiment. Several students became frustrated. "I don't get it," said Erin Baumann, 12. Other students nodded in sympathy.

Disappointed, Gutman had to repeat the lesson before moving to new material. To save time the next day, she showed students how to find the solution instead of letting them do it. Because of the way her school schedules it classes, on some days Gutman has twice the time to teach the lesson. But even then, it's often not enough.

"I'm always looking at the clock," Gutman said. "If I had these kids an hour and a half a day, five times a week, I know their test scores would be higher."

Nationwide, many schools have begun raising their standards in math. But the study has raised cautions about that charge. Higher standards will not be meaningful, it contends, if teachers are chronically short of time in class and are judged largely by how well they get through a textbook each year.

Using a textbook is not an inherently bad idea; most are selected to match the goals schools have for students, and they lend structure to a class. But a teacher who focuses too much on plowing through material can lose sight of whether students are learning. There are often more creative ways to engage students, the study suggests.

It also reveals differences in teaching styles. One of its chief features was videotaped analysis of how American math classes are taught, compared with instruction in nations where schools seem to be having more success.

Researchers said they found striking consistency in the habits of American teachers, even though, unlike most other industrial nations, the United States does not have a strict national model for curricula or teaching training.

"When you look at it, you really think there is a formal American style," said James Stiegler, a psychology professor at UCLA who coordinated the videotaping project. "We found that American teachers develop concepts far less frequently. We tend to practice routine math procedures more than anything else."

There were other distinctly American habits: Teachers put great emphasis on praising students. Many also created drills to give students some taste of academic success, in part by deliberately asking questions with obvious answers.

Those tactics, in moderation, are not all bad, the study contends. Some students can be served well by the approach, and some of the teaching traits found in other nations -- like the total absence of praise for students -- struck researchers as too harsh.

Still, they worry that American teachers dwell too much on praising students for simple accomplishments and lack the patience to let students gradually discover lessons on their own -- a process some educators dub the "Aha!" phenomenon.

"American teachers were very uncomfortable with having students confused for even a little while," Stiegler said. "You see them stopping a lesson and rushing over to a student saying, `Let me show you how.' In Japan and other countries, teachers like to let kids struggle, even have the wrong answers for a while, to try to get them to discover something. When they do, they seem to have more mastery of a lesson."

There is still great tension among math educators about which approach is best. Some say the study overstates the benefits of teaching "concepts" and ignores the value of other methods. Some school systems are still designing curricula that stress equation-solving skills and abstract thinking. Those methods, they insist, have been successful for generations of students.

At Fairfax's Jackson Middle School, the curriculum includes much of what the study advocates. Even the length of classes has been expanded. Yet how material is taught still varies. The reasons for that, teachers say, are compelling: lack of time to prepare, lack of training, and too much material to cover.

Pair, the eighth-grade teacher, said the need to prepare students for high school often overwhelms his effort to try new teaching styles. But Jackson Principal Michael Doran said teachers sometimes feel that pressure too keenly.

Jackson is narrowing the aims of math instruction to give teachers freedom to try new approaches. But Doran said that too often math is merely one of many pressing priorities in schools. "We try to do too much," he said. "If we're going to be so good at math, we might have to give up something as a nation. And it might not be worth it."

There are other hurdles. Pair said he is torn between his desire to applaud the effort of struggling students and the need to push them harder to master fundamentals. That tension is exacerbated by the county's new grading philosophy, which requires educators to assess a student's progress, not just test scores.

Pair also said there is a philosophical issue: Should teachers focus on topping international comparisons, or work harder to improve students who struggle? He worries the newer methods could leave some students behind.

"I like to think of myself as a teacher who can raise the bottom rather than lift the roof off," Pair said. "What matters to parents is, `Do you know my kid? Is my kid doing better? Is my kid going to be prepared for the next step?' "

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