EDUCATION WEEK
AMERICAN EDUCATION'S NEWSPAPER OF RECORD

VOL. 27, NO. 34 • APRIL 23, 2008 • $3
edweek.org: BREAKING NEWS DAILY

IN PERSPECTIVE

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Catching Up On Algebra

More schools are using unconventional textbooks and other curriculum materials to help make struggling middle schoolers 'algebra-ready.'

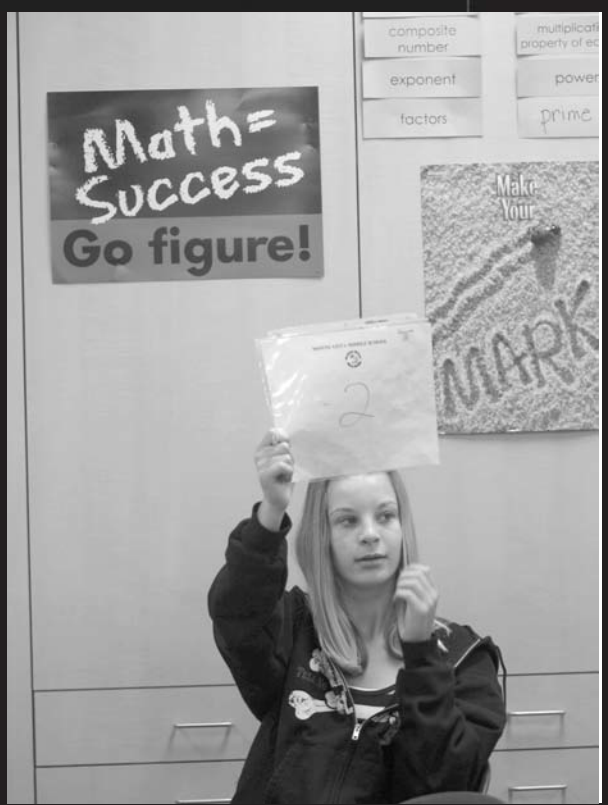
Camarillo, Calif.

A popular humorist and avowed mathphobe once declared that in real life, there's no such thing as algebra. Kathie Wilson knows better.

Most of the students in her 8th grade class will be thrust into algebra, the definitive course that heralds the beginning of high school mathematics, next school year. The problem: Many of them are about three years below grade level. Ms. Wilson's job is to help them catch up—and quickly.

Every year, scores of middle and high school math teachers face the same challenge as Ms. Wilson, who is in her eighth year of teaching here at Monte Vista Middle School, tucked into the exurbs about an hour north of Los Angeles.

The push to ensure that all students, not just the academically gifted, take



Eighth grader Jill Jordan holds up her answer to a math problem at Monte Vista Middle School, which uses materials that rely on illustrations.

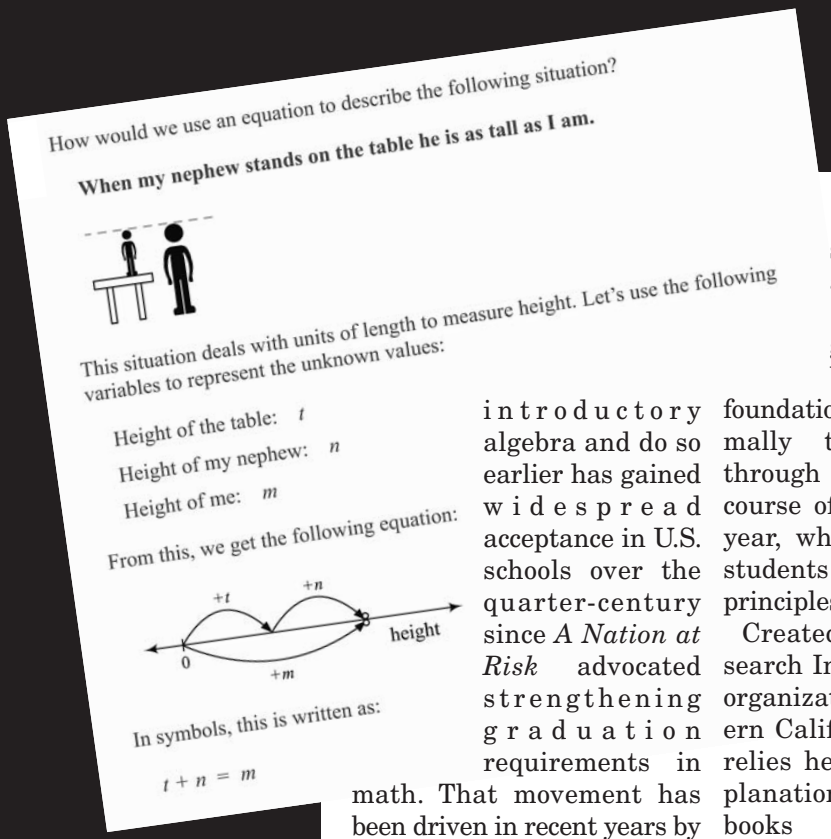
By Sean Cavanagh
Photographs by Ann Johansson

A NATION AT RISK

25 Years Later

THE MATH EQUATION

In 1983, when *A Nation at Risk* was released, many Americans feared that Japan or Germany would overtake the United States as the world's pre-eminent economic power. To help ensure that the nation maintained its place in the global arena, the authors of the report recommended that the country build up its mathematical might. They urged that students take at least three years of high school math to earn a diploma, and that they acquire in the preceding years "a sound base" in "computational and problem-solving skills."


How would we use an equation to describe the following situation?

When my nephew stands on the table he is as tall as I am.

This situation deals with units of length to measure height. Let's use the following variables to represent the unknown values:

Height of the table: t

Height of my nephew: n

Height of me: m

From this, we get the following equation:

In symbols, this is written as:

$t + n = m$

A graphic from a MIND Research Institute textbook shows students how to use an equation to describe a specific situation—a skill needed in algebra—by presenting visual and symbolic representations of that problem.

"Giving the same old material to students—it hasn't worked for eight years. I don't see why it would work the ninth time around, either."

–JIM SHORT
on why the Oxnard Union High School District switched programs

introductory algebra and do so earlier has gained widespread acceptance in U.S. schools over the quarter-century since *A Nation at Risk* advocated strengthening graduation requirements in math. That movement has been driven in recent years by rising state and local high school standards, which in turn have forced higher expectations for courses taught in middle schools. One result of those efforts is that beginning algebra is being taught earlier, typically in the 8th rather than the 9th grade.

Now, after years of raising the standards, some policymakers are moving to help thousands of middle and early high school algebra students who cannot keep up.

Last year, for the first time, California state officials approved an entire set of math programs devoted specifically to "algebra readiness," or raising the skills of students likely to struggle in that subject. Similar algebra-readiness materials are being used in other states and districts around the country.

The strategy Ms. Wilson is trying in her classroom is simple yet ambitious.

She uses a program aimed at rebuilding students' foundational math skills, normally taught from 2nd through 7th grade, over the course of a single academic year, while introducing the students to basic algebraic principles and language.

Created by the MIND Research Institute, a nonprofit organization based in Southern California, the program relies heavily on visual explanations of math in textbooks and computer software. The approach is meant to engage and motivate students, and build a bridge between elementary math and algebra.

It is also designed to help students of different ability levels, such as those in Ms. Wilson's class who have shaky English-language skills. The program's visual model helps students connect different math concepts and remember them, its developers say.

"The way I was taught growing up, you just memorize the algorithms and you'll learn the math," Ms. Wilson said during a break from her class one day this semester. "This [new approach] is taking the math and showing them why it works, and building it up for them."

Setting the Bar

Along with California, a number of other states have crafted programs aimed at girding struggling students for introductory algebra. Virginia oversees a statewide algebra-readiness program for students in grades 6-9; roughly 60,000 tests are given each year to determine whether students need extra help. Kentucky is supporting an algebra-readiness pilot program in several districts. Many school systems nationwide, of all sizes, have launched their own efforts.

Interest in such programs has coincided with the nationwide drive to teach algebra earlier.

From 1996 to 2005, the proportion of U.S. students who reported taking Algebra 1 as 8th graders climbed from 24 percent to 34 percent, though the share varies enormously by state, according to the Council of Chief State School Officers. California raised the algebra bar considerably in 1997, when it adopted standards that encouraged all students to take Algebra 1 in 8th grade. The state later required all students to complete Algebra 1 to graduate with a regular high school diploma.

By some measures, those steps appear to be having the desired effect. The percentage of California 8th graders taking Algebra 1 has risen with the tougher standards, according to testing data, and the proportion of students who have not enrolled in that course by jun-

ior year has declined, an independent report showed.

Yet many California students are still falling short.

Just 23 percent of the 740,000 middle and high school students who took the state's end-of-course Algebra 1 exam reached proficiency in 2007, roughly the same proportion as four years earlier. By contrast, 40 percent scored "proficient" or better on the state's test of 7th grade math.

In an attempt to help those students, the California state board of education last year adopted 11 separate algebra-readiness programs. That action enables districts to use state money to buy those textbooks and classroom materials. The programs target 8th graders, but districts can use the programs in other grades, too.

Those resources have been welcome in the 16,500-student Oxnard Union High School District, which accepts students from Monte Vista and several other feeder middle schools. The district is piloting two of the new algebra-readiness programs, including the one developed by the MIND Research Institute, for use in 9th grade.

The needs in the Oxnard Union district are clear. Roughly 40 percent of its freshmen arrive unprepared for Algebra 1 or higher math, according to Jim Short, the district's math specialist.

"Giving the same old material to students—it hasn't worked for eight years. I don't see why it would work the ninth time around, either," Mr. Short said. Too much math teaching today, he argues, pushes students through "the same standards repeatedly, without really getting at the underlying foundations."

Of the algebra-readiness strategies, he said: "I definitely believe [they] will help."

Numbers to Symbols

Completing introductory algebra, and doing so relatively early, benefits students later on, research suggests. A 2005 federal study found that more than 80 percent of students who took Algebra 1 as 9th graders went on to complete Algebra 2 or an advanced math class, such as calculus, during high school. Only 29 percent who did not follow that schedule ended up finishing upper-level algebra or calculus.

Still, algebra has long represented as much a psychological hurdle for students as an educational one.

Most of the math that students encounter in elementary school is relatively concrete: whole numbers, fractions, one- or two-step procedures, problems like 7 x 8 = 56.

Algebra, for many students, is a departure from the concrete. In the simplest terms, it's the study of relationships between numbers, with some numbers represented as symbols. It deals with equations, functions, and polynomials, and problems like 2x + 3y = 56, when x = 6.

Many students struggle with those kinds of problems, or fail to see the point of them (as did the comic essayist Fran Lebowitz, the author of the put-down about algebra having no connection to real life).

"Algebra is a pretty big leap in abstraction," said Jon R. Star, an educational psychologist at Harvard University who has studied how students understand math.

For many students, Mr. Star said, "ideas about *x* and *y* just don't make sense." U.S. schools, he said, have struggled to "help students make that leap."

The goal of having more students—ideally, all of them—take Algebra 1 in 8th grade dates at least as far back as the 1960s, and the idea gained popularity over the following two decades, math scholars say.

One factor was the belief that many middle schoolers were not being challenged by math lessons that were redundant and too focused on arithmetic. But probably the biggest influence was the view that American schools were arbitrarily denying academic and economic opportunity to entire groups of students, by giving some the chance to take 8th grade algebra and relegating others to more basic math.

It became "an equity issue," said Jeremy Kilpatrick, a professor of mathematics education at the University of Georgia, who has examined the history of algebra teaching in U.S. schools. Without algebra, "not only were your chances of getting into college reduced, but your chances for majoring in certain subjects were reduced," he said. "Algebra was the ticket."

At the same time, policymakers were calling for higher standards. *A Nation at Risk*, the influential federal report released in April 1983, lamented that relatively few American students reached advanced algebra. It called for students to complete a minimum of three years of high school math and identified "algebraic concepts" as core content.

Not surprisingly, the public tends to see algebra as important mostly because schools, colleges, and test developers see it as important, said Zalman Usiskin, the director of the University of Chicago School Mathematics Project and a prominent researcher and textbook author.

But contrary to popular opinion, algebra has great value in everyday life, Mr. Usiskin said.

Algebra helps people solve problems that require them to consider several quantities that depend on each other,

In her office at Monte Vista Middle School, Kathie Wilson prepares for a lesson. Like many algebra teachers nationwide, she needs to rebuild the math skills of 8th graders.

he explained. Calculating the payment on a car or a house using different interest rates can be simpler with algebra, as is figuring out how health is affected by factors such as diet, body weight, and age, Mr. Usiskin wrote in a 1995 essay on algebra's importance.

"You can live without it, but you will not appreciate as much of what is going on around you," Mr. Usiskin reasoned in that article. "You will be more likely to make unwise decisions, and you will find yourself with less control over your life than others who have this knowledge."

Coming up with strategies to prepare students better for algebra has been a major focus of policy experts in recent years. The National Mathematics Advisory Panel, a White House-commissioned group, released a report last month that calls for a more logical progression through foundational math, particularly in whole numbers, fractions, and geometry and measurement, as a primer for algebra. *(See Education Week, March 19, 2008.)*

Review and Rebuild

This school year, Monte Vista Middle School's Ms. Wilson has returned to the foundations of math continually. When introducing her 8th graders to a topic such as fractions, she often begins with material typically found in a relatively early grade, then gradually moves into more complex problems, blending in algebraic concepts along the way.

A View From Abroad: Algebra Comes Early

While more American students are being encouraged to take introductory algebra in 8th grade, their foreign peers are typically exposed to that math content by at least that grade level, if not earlier, a well-known scholar has found.

Research conducted by William H. Schmidt, a professor of education at Michigan State University in East Lansing, has shown that many Asian and European countries teach introductory algebra in 8th or even 7th grade, and seek to prepare students for that material in earlier grades. Those courses usually aren't called Algebra 1, as they are in the United States, even though they cover algebraic material, he said.

Mr. Schmidt studied algebra and math coursetaking in about 50 foreign nations with varying levels of academic achievement in the mid-1990s; their curricula have remained relatively unchanged since then, he said.

The researcher says he believes all U.S. students should be encouraged to take introductory algebra by 8th grade—and be adequately prepared for it beforehand. In American middle schools today, "there's a tracking," Mr. Schmidt said, in which "some kids get Algebra 1 and others don't."

—SEAN CAVANAGH

The idea is to give students both a refresher on the basics and a taste of the language and thinking required in algebra, according to the MIND Research Institute, the group that developed the program.

In a class one day this semester, Ms. Wilson sought to bridge the divide between basic arithmetic and algebra during a lesson on prime factorization. She writes out 24/18 on the board, then asks students to factor out the fraction using prime numbers—those that can be divided only by themselves and the number 1. For the numerator, 24, they write out 2 x 2 x 2 x 3, for 24. Then she asks them to simplify that expression.

"How many of you got 4/3?" Ms. Wilson asks. Most of the students raise their hands.

Lessons on prime factorization with whole numbers is probably 4th grade material, the teacher says. But that relatively simple skill becomes crucial later in algebra, she points out, when students will be asked to factor using variables and eventually rational expressions.

Her classroom is set up to motivate them for the tasks ahead. A chest-high number line spans the length of one wall. Paper images of famous mathematicians, from Pythagoras to John Nash, the real-life basis for the movie "A Beautiful Mind," hang from the ceiling. Later in the class, Ms. Wilson leads students to Monte Vista's computer lab, where they work on a software program that reinforces the day's lessons visually.

Jill Jordan, 13, uses a mouse to trace a number line on her computer's screen, then clicks to identify the prime numbers.

When she chooses a number, it reconfigures into a series of blocks that show her visually why it is prime or composite, and she moves on to a larger one. At number 91, she misses—it's a composite number, not prime, as she thought—and she's sent back to the 70s.

Jill can easily identify the math that vexes her the most. "Multistep problems," she says. "The ones that go on forever." But she says her confidence has grown over the course of this school year.

Using visual reinforcements, through software and texts, to improve students' math learning was the goal of Matthew Peterson, the creator of the algebra-readiness model for the MIND Research Institute.

Mr. Peterson, 35, co-founded the nonprofit organization while working on his Ph.D in neuroscience from the University of California, Berkeley. His doctoral thesis focused on spatial and temporal processes in the visual cortex of the brain. He now applies visual neuroscience to math.

The scientist had a personal connection to the subject. Mr. Peterson struggled early in school with dyslexia. He didn't learn to read until 5th grade. Math, to him, seemed like an assortment of disconnected facts.

It wasn't until his father, a doctor, encouraged him to use visual clues to help him learn that math and other subjects began to make sense. Even today, he regularly sketches out drawings—on scratch paper, on the whiteboard in his office—to help him remember things and order them.

The pictures and images in the MIND Research Institute's algebra-readiness textbooks and the accompanying software are meant to have a similar effect on struggling students, Mr. Peterson explained in an interview at the organization's headquarters, in an office plaza in Santa Ana, Calif.

"There's not enough [emphasis] today on how you build visual-learning environments for students," Mr. Peterson said. Many struggling students get lost in multistep problems because they forget the processes needed to solve them. Visual clues act "like a crutch" to remind them, he said.

Another algebra-readiness program, developed at the University of California, Los Angeles, and adopted by state officials, takes a different strategy.

The program provides students with weekly, disposable packets of math lessons, rather than textbooks. The goal is to make the materials less intimidating and more engaging than traditional texts, said Shelley Kriegler, who worked on it as the director of UCLA's Math Content Program for Teachers and Students. To keep it simple and inexpensive for districts to implement, the program does not use computer software.

Struggling students look at traditional, thick math textbooks and "tend to check out," Ms. Kriegler said. Those students, she said, need "a fresh start" with algebra.

New entries into algebra are showing promise at Sierra Intermediate School, in Santa Ana, according to Brad Sterling, a math teacher there.

He's using the MIND Research Institute's algebra-readiness program, though modifying it slightly to reinforce key math vocabu-

lary—terms like "estimate" and "difference." The school, located in the 55,000 Santa Ana district, is overwhelmingly Latino, and the language-builders help.

Mr. Sterling's first teaching job was at a private middle school in San Diego, where he could give students algebra problems and they would breeze through them. Today at Sierra, students arrive in the 24-year-old's class in need of basics. "Can you help me divide?" he has been asked.

On this day, he begins with addition and subtraction of fractions. Then, using an overhead projector, he asks students to plot fractions on a number line. It's a step toward algebraic thinking.

So far, he believes, the new approach to algebra is helping. His students' skill in number sense and other areas has jumped. Their scores rose sharply on a recent district benchmark test in math. And the visually oriented computer lessons lend variety to his classes, which keeps students interested, he said.

Many of his students see a math book and say, " 'Oh, I can't do it,' " Mr. Sterling explained. The algebra-readiness model, he said, "sets them up to do well in the beginning. It's getting them to the point where they have the confidence to do it." ■

Special coverage marking the 25th anniversary of the landmark report A Nation at Risk *is supported in part by a grant from the Broad Foundation.*

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Education Week is published 44 times per year by Editorial Projects in Education Inc. Subscriptions: U.S.: $79.94 for 44 issues. Subscriptions: Canada: $135.94 for 44 issues.

"You will be more likely to make unwise decisions, and you will find yourself with less control over your life than others who have this knowledge."

–ZALMAN USISKIN
on why algebra is important to people's everyday lives