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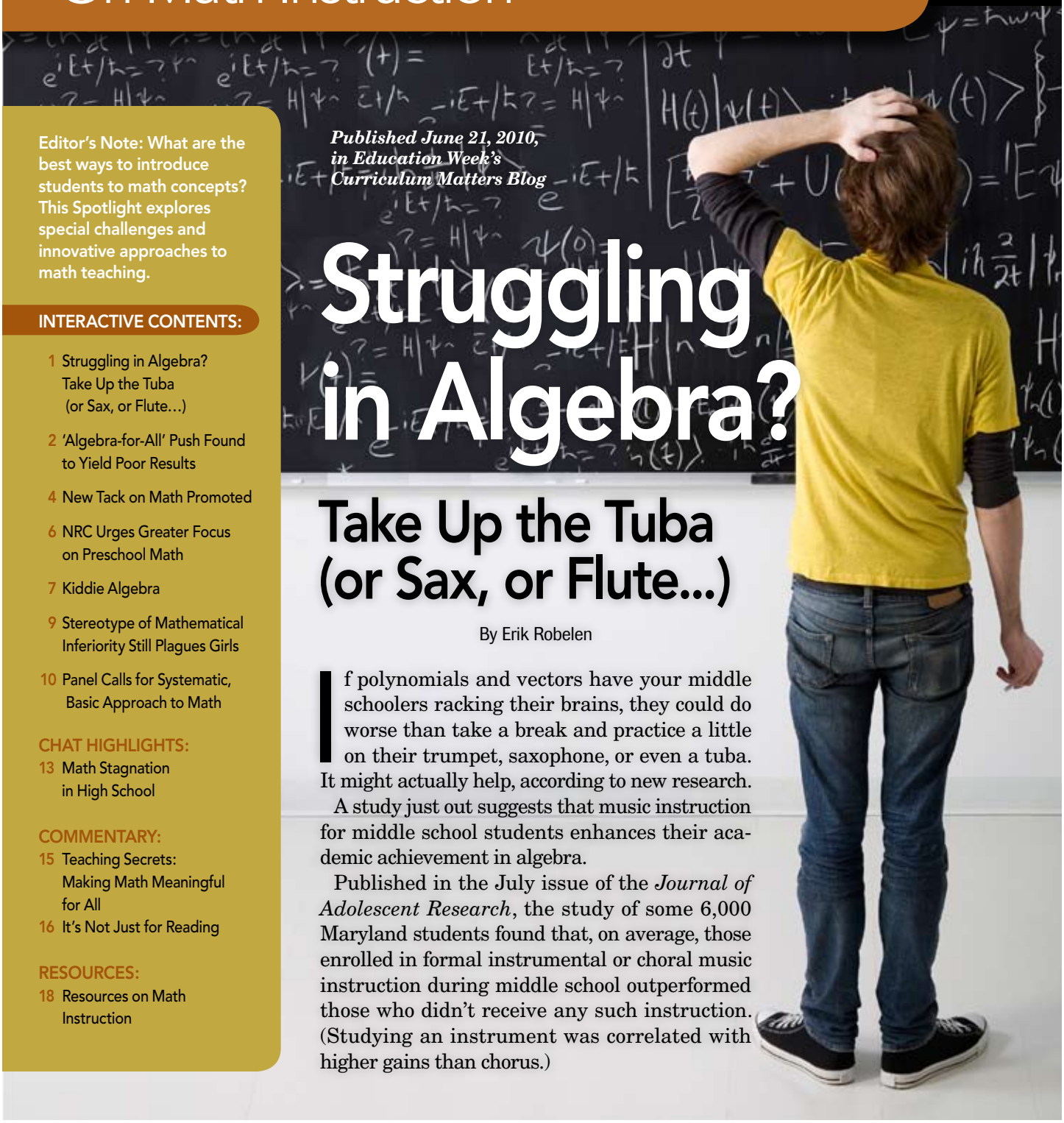
SPOTLIGHT

On Math Instruction

Editor's Note: What are the best ways to introduce students to math concepts? This Spotlight explores special challenges and innovative approaches to math teaching.

INTERACTIVE CONTENTS:



Published June 21, 2010, in Education Week's Curriculum Matters Blog

Struggling in Algebra?

Take Up the Tuba (or Sax, or Flute…)

By Erik Robelen

If polynomials and vectors have your middle schoolers racking their brains, they could do worse than take a break and practice a little on their trumpet, saxophone, or even a tuba. It might actually help, according to new research.

A study just out suggests that music instruction for middle school students enhances their academic achievement in algebra.

Published in the July issue of the *Journal of Adolescent Research*, the study of some 6,000 Maryland students found that, on average, those enrolled in formal instrumental or choral music instruction during middle school outperformed those who didn't receive any such instruction. (Studying an instrument was correlated with higher gains than chorus.)

istock/ Diane Diederich

The author suggests that the key factor may well be the type of brain development happening during the middle school years.

To be clear, this was not a random-assignment study. The researcher, Barbara H. Helmrich, an adjunct professor at the College of Notre Dame of Maryland, relied on test data and related information on students in six school districts across Maryland who opted to get music instruction compared with those who did not.

"Due to the nature of educational choice in music, a true experimental situation was not feasible," Helmrich writes.

That said, she did try to control for certain factors, such as students' prior math achievement and their race (African-American and white).

Factoring in prior achievement did reduce the measured benefit, but it was still significant, Helmrich says. The study finds that African-American students appear to receive a greater degree of academic benefit in algebra than white students from studying music. Furthermore, she says that "music instruction exerts a greater influence on students who are not accelerated," though she cautions that "one does not expect that formal music instruction alone can completely compensate for little mathematical ability."

She writes: "The extent of [the] connection between music and algebra achievement most likely lies in a combination of factors."

In an e-mail to me, she further discussed the study: "I suggested that the middle school years might offer a window of opportunity for formal music instruction to impact (in this case algebra) achievement because of what is occurring in the brain at that time. New synapses are being formed in cortical areas that both music and mathematics access."

She added: "I suggested that learning and practicing music strengthens those connections. Those same strengthened synapses would then be utilized when performing algebra. Although I believe the results support my theory, I also discuss other possible explanations for my results."

Published February 10, 2009, in Education Week

'Algebra-for-All' Push Found to Yield Poor Results

By Debra Viadero

Spurred by a succession of reports pointing to the importance of algebra as a gateway to college, educators and policymakers embraced "algebra for all" policies in the 1990s and began working to ensure that students take the subject by 9th grade or earlier.

A trickle of studies suggests that in practice, though, getting all students past the algebra hump has proved difficult and has failed, some of the time, to yield the kinds of payoffs educators seek.

Among the newer findings:

• An analysis using longitudinal statewide data on students in Arkansas and Texas found that, for the lowest-scoring 8th graders, even making it one course past Algebra 2 might not be enough to help them become "college and career ready" by the end of high school.

• An evaluation of the Chicago public schools' efforts to boost algebra coursetaking found that, although more students completed the course by 9th grade as a result of the policy, failure rates increased, grades dropped slightly, test scores did not improve, and students were no more likely to attend college when they left the system.

• A 2008 paper by the Brookings Institution suggested that as many as 120,000 students nationwide were "misplaced" in algebra programs, meaning they had test scores on national exams that put them about seven grades below their peers in algebra classes. Further, it said, states with a high proportion of students taking algebra in 8th grade didn't necessarily outperform other states on national math assessments.

"Simply sticking students in courses without preparing them ahead of time for the class does not seem to work as an intervention," said Chrys Dougherty, the author of the Arkansas and Texas analysis, published last month by the National Center for Educational Achievement, in Austin, which is owned by the test publisher ACT Inc. "It seems to work with adequately prepared students, but not for the most challenged students."

> "The reason studies like mine show that students even with low levels of achievement do better in advanced classes is because the low-level classes are practically worthless."
>
> ADAM GAMORAN
>
> Professor of Education Policy Studies and Sociology, University of Wisconsin-Madison

The research news has not been completely bad, however.

Greatest Gains

Michigan State University researcher William H. Schmidt, in a not-yet-published study, analyzes data on 7,000 7th and 8th graders across the United States who took part in the Third International Mathematics and Science Study in 1995. He compared the performance of 8th graders with that of "feeder classes" of 7th graders from the same school to calculate how much students gained in mathematics over the course of that pivotal 8th grade school year.

An 8th grade algebra class, in other words, might be matched with a 7th grade prealgebra class, or a 7th grade general-math class paired with an 8th grade prealgebra or general-math class in which students had similar achievement levels.

What Mr. Schmidt found was that the learning gains were greatest for students who moved from either a general math class or a prealgebra class into a full-blown algebra class.

His findings are in keeping with a larger

body of studies from the 1990s and early 2000s that suggested algebra was, for many students, the primary gateway to advanced-level mathematics and college. The problem was that too many students—particularly those who were poor or members of disadvantaged minority groups—were turned away at the gate, screened out by ability-grouping practices at their schools.

"There's no question that taking advanced courses boosts student achievement," said Adam Gamoran, a professor of education policy studies and sociology at the University of Wisconsin-Madison. His 2000 study on algebra and tracking helped catalyze the interest in expanding access for all students to algebra courses.

"Where the area of disagreement comes," Mr. Gamoran added, "is what should we do with students who performed poorly previously. In my judgment, the reason studies like mine show that students even with low levels of achievement do better in advanced classes is because the low-level classes are practically worthless."

"And there's no simple solution to this problem," he added, "because we also know that when tracking is eliminated, students at high levels don't gain as much as they do in high-level or [Advanced Placement] classes."

That's some of what Chicago found when it made a concerted effort to expand enrollment in college-preparatory classes, including algebra, according to the study on that district's initiative. The Consortium on Chicago School Research published the evaluation late last year.

"For the high-achieving kids, there was a big change in the classroom composition, so that changes the quality of classes," said study co-author Elaine M. Allensworth, the interim co-executive director at the consortium, an independent research group based at the University of Chicago. "That means you have to have teachers who can teach to all classes, and it also means you don't have an elite group of students who may be getting better advising in smaller classes."

"Meanwhile, the kids who weren't taking advanced classes before are taking them now," she said, "but they're not very engaged in them. They have high absence rates and low levels of learning."

As the trends became evident, the school system in 2003 began requiring 9th graders who scored below the national median on standardized math tests in 8th grade to take an algebra "support" class in addition to a regular algebra class. Students who scored higher continued to take a single period of algebra.

For the Chicago consortium's study, the researchers compared outcomes for students just above and below the cutoff for the "double dose" classes.

Worried about the potential for reintroducing tracking, the district also provided professional-development workshops and other resources to the teachers of the support classes, according to Ms. Allensworth.

"Because teachers had more time and resources, the instructional quality in those classes improved quite a bit," she said. "But the classes ended up concentrating more students with attendance and behavioral problems."

In the end, the study found, failure rates increased for both the targeted students and for their peers in single-period algebra classes. On the other hand, algebra test scores rose substantially for the students in the double-dose classes.

"The district thought [the double-dose initiative] was a failure because it did not improve pass rates, but our analysis showed that test scores improved a lot," Ms. Allensworth said.

Catching Up

Part of the problem, the Chicago researcher said, is that schools have little guidance on how to structure algebra programs to serve all students.

"Even though everyone's using double algebra periods these days, there's not a ton of research on this," Ms. Allensworth said. One exception, she noted, is studies of the Talent Development model developed by researchers at Johns Hopkins University in Baltimore, which incorporates double-dose classes as part of a broader set of reforms.

The 48,000-student Garden Grove Unified School District in Orange County, Calif., turned to a multipronged approach to increase algebra success rates in the highly diverse district.

According to Gabriela Mafi, the associate superintendent for secondary education, students who are likely to struggle in a regular, single-period algebra class are directed to take either an additional "companion" algebra class or "algebra readiness," with the expectation that students in the latter course will take regular algebra the following year.

The most advanced students take either geometry or a single period of algebra. While there hasn't been a scientific evaluation of the district's algebra efforts, Ms. Mafi said, passing rates for algebra and other advanced-math courses have gone up over the past four years.

"I think the issue is that it's not one-size-fits-all," she said.

The Garden Grove district in 2004 won the Broad Prize for Urban Education, bestowed by the Los Angeles-based Eli and Edythe Broad Foundation, for its efforts at improving achievement among all student population groups.

'Basic Arithmetic'

Tom Loveless, the author of the report from the Washington-based Brookings Institution on "misplaced" math students in algebra, said the issue is even more complex.

"No one has figured out how to teach algebra to kids who are seven or eight years behind before they get to algebra, and teach it all in one year," said Mr. Loveless, who favors interventions for struggling students at even earlier ages.

Nationwide, research findings may diverge because testing content varies—the TIMSS test has more algebra content than many state exams taken by 8th graders—and because course content varies from classroom to classroom.

"If you take what's called algebra class, and you look at the actual distribution of allocated time, you find that many of those teachers spend a very large portion of that year on basic arithmetic," said Mr. Schmidt, who is a distinguished university professor of education at Michigan State's East Lansing campus. His research on U.S. classrooms has found, in fact, that nearly a third of students studying algebra are using arithmetic books in their classes.

Likewise, Mr. Loveless' study found that "misplaced" students tended to attend large urban schools where their teachers were more likely to have less than five years of experience, less likely to hold a regular teaching certificate, and less likely to have majored in math than teachers of typical 8th grade algebra students.

"It may well have more to do with whether students have been given adequate opportunities to learn this stuff," Mr. Schmidt said of the disappointing findings that have emerged from some studies.

Published October 7, 2009, in Education Week

New Tack on Math Promoted

Problem-Solving Is Focus of High School Guide

By Sean Cavanagh

Three years after calling for a reordering of elementary and middle school math curricula, the nation's largest group of math teachers is urging a new approach to high school instruction, one that aims to build students' ability to choose and apply the most effective problem-solving techniques, in the classroom and in life.

Cultivating those skills will make math more useful, and more meaningful, to students, the National Council of Teachers of Mathematics argues in a document scheduled for release this week.

"Focus in High School Mathematics: Reasoning and Sense Making" is a follow-up to the NCTM's 2006 document, "Curriculum Focal Points," which offered grade-by-grade content standards in math for prekindergarten through 8th grade. "Focal Points" won general praise in math circles, even from some of the NCTM's strongest critics.

The high school document has both a different purpose and a different structure. It is not a suggested set of content standards, but rather a framework that attempts to show how skills that the NCTM considers essential—reasoning and sense-making—can be promoted across high school math.

While the new guidelines say that understanding math content and procedures is important, they also argue that students need to learn to apply that knowledge in different situations—a skill that proves essential in everyday situations and in the workforce.

"Reasoning and sense-making are at the heart of mathematics from early childhood through adulthood," NCTM President Henry S. Kepner Jr. says in an introduction to the document. Cultivating those skills, he writes, "will prepare students for higher learning, the workplace, and productive citizenship."

NCTM officials also argue that those abilities will help produce more students who are more interested in, and capable of, going into math- and science-centered occupations, a major concern of American policymakers.

"We keep teaching that learning to carry out complicated procedures is what math's about," said W. Gary Martin, a professor of mathematics education at Auburn University, in Alabama, who chaired the committee that wrote the document. "To me, the real question is, can [students] do anything with it?"

The 100,000-member math teachers' group, based in Reston, Va., is releasing the document at a time when policymakers at the federal and state levels are pushing for more consistency in what students are taught.

Something in Common

Forty-eight states have agreed to take part in a venture called "Common Core," designed to produce common standards in language arts and math. It is being led by two organizations that work with states, the Council of Chief State School Officers and the National Governors Association. The NCTM is one of several organizations that have offered comments on a draft of the math section, which is organized by content area and focuses on preparation for college and the workforce. *(See Education Week, Sept. 30, 2009.)*

NCTM officials provided a prepublication copy of the high school report to the Common Core authors, said Jason Zimba, a professor of mathematics and physics at Bennington College, in Vermont. The two documents touch on many of the same main ideas, he said.

"They ought to be reinforcing," said Mr. Zimba, who is a member of the Common Core math working group. "We've been trying to be on the same page the whole time."

Both documents, for instance, emphasize mathematical practices, or students' ability to adapt math strategies to solve new problems, although they describe those skills in somewhat different language.

New Meaning in Math?

The NCTM's high school guidelines explain how reasoning and sense-making can be applied in different areas of math. They also offer numerous examples of how such applications might play out in the classroom, presented through model dialogues between teachers and students covering math lessons.

Focusing on reasoning will not saddle teachers with additional burdens, but rather produce more engaged students, the NCTM authors argue.

"Currently, many students have difficulty because they find mathematics meaningless," they write. "Without the connections that reasoning and sense-making provide, a seemingly endless cycle of reteaching may result."

The NCTM did not organize "Focus in High School Mathematics" by grade, partly because American students take different classes, such as introductory and advanced algebra, at so many different points in high school, Mr. Kepner explained in an interview.

While "Curriculum Focal Points" was aimed mostly

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> W. GARY MARTIN
>
> Professor of Mathematics Education, Auburn University

at state officials, curriculum developers, and publishers, the high school document is mostly targeted to "instructional leaders," such as teachers, curriculum specialists, and administrators, in addition to state officials and the publishing industry, Mr. Martin said.

The NCTM published voluntary academic-standards documents in 1989 and 2000, which have shaped curriculum, instruction, and textbooks nationwide. Critics have said those standards paid too little attention to crucial math content and strayed from standard problem-solving approaches.

With the publication of "Focal Points" three years ago, the NCTM won over some detractors, who said the document offered clear guidance to schools on elementary and middle school math.

More Content Wanted

Early reaction to the high school document was mixed.

Albert Cuoco, who directs the Center for Mathematics Education at the Education Development Center, in Newton, Mass., called the NCTM publication a "breath of fresh air."

Mr. Cuoco said other standards documents and resources, such as a 2008 report by the White House-commissioned National Mathematics Advisory Panel formed during the second Bush administration, have sought to present "clear and unambiguous" lists of essential math topics. What's missing for many teachers is "the glue that holds them together," or a sense of how those topics relate to one another and why they are important, said Mr. Cuoco, whose center works on math curriculum, teacher training, and policy.

The NCTM's new document and others like it that explain in plain language why topics matter represent "a new genre in framework-writing," Mr. Cuoco said.

Mr. Cuoco, who reviewed a draft of the document, was less enamored with its use of hypothetical examples designed to demonstrate how reasoning works in math class, many of which describe a teacher interacting with "student A" or "student B." Mr. Cuoco said he would have preferred more direct testimonies provided by actual teachers. "It didn't ring true to me," he said.

Vern Williams, who served on the national math panel and has been critical of the NCTM, said he did not want to make extensive comments on the document until he had read it in more detail. But he said the language in the publication reminded him of the NCTM's 1989 standards, which he believes promoted a weak approach to math instruction, as opposed to "Focal Points," which he regarded as much more content-rich and useful.

"It would be nice if the content was described more," said Mr. Williams, a math educator at Longfellow Middle School in Fairfax County, Va., who has won a number of awards for his teaching. "It's too vague."

Wilfried Schmid, another math panelist and a math professor at Harvard University who also was critical of the NCTM's 1989 and 2000 standards, said he agreed with the organization that nurturing math reasoning skill is important, and that many students become overly reliant on procedures.

But he said the new document places too much emphasis on "abstract" skills, rather than on math content and math "as a sequential subject." There needs to be more of a balance between content knowledge and reasoning and problem-solving ability, he said.

"They are diagnosing a problem, and I largely agree with the diagnosis," Mr. Schmid said, but the high school document "would lead to a worse situation."

Mr. Kepner countered that the NCTM was trying to avoid repeating or adding to the long list of math content topics promoted in individual states. It instead wanted to "go further" in giving that content greater meaning for teachers and students, he said.

Other Resources Coming

In an effort to make "Focus in High School Mathematics" useful to the public, the NCTM is also publishing short, separate resources that translate the document for teachers, administrators, policymakers, and families.

The organization also plans to publish additional "topic books" to explain how reasoning and sense-making can be cultivated in different areas of math, such as in algebra and geometry, in greater detail than the current document does.

"This is only the first step," said Mr. Martin of Auburn University. Overall, NCTM officials hope the document will help high school students see the relevance of math, and improve their performance, which on national tests has been mostly stagnant for decades.

At times, high school math instruction "seems impervious to change," Mr. Martin said. "It's just a Herculean task. ... We can't just keep going down the same path. We keep repeating the same mistakes, year after year."

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NRC Urges Greater Focus on Preschool Math

By Sean Cavanagh

Early-childhood education, whether delivered through federal preschool programs or other means, needs to be revamped to place more emphasis on math instruction and prepare adults to cover that material more effectively, a new report concludes.

The report, released today by the congressionally chartered National Research Council, reiterates a point commonly made by early-childhood advocates: that mathematics is often neglected in prekindergarten settings, in contrast to the heavy focus placed on literacy.

That neglect stems in part from preschool instructors' lack of comfort with math, as well as parents' fear of that subject, the authors say.

"It's fair to say the attention is almost entirely on reading and literacy, without recognizing the importance of math," said Christopher T. Cross, who co-edited the report and chaired the committee that produced it.

That lack of attention comes despite research that shows many young students arriving in preschool with an ability, and a willingness, to tackle math lessons, added Mr. Cross, the chairman of Cross & Joftus, an education policy consulting company based in Washington and California.

"There's a natural curiosity about mathematical things," he added, "even if they don't call it math."

Patchwork System

The consequences of not providing an early math foundation to disadvantaged students, given their more limited opportunities to learn the subject away from school, can be especially great, the authors found. At the same time, high-quality math instruction can help overcome "systematic inequities in educational outcomes and later career opportunities," they say.

The report focuses primarily on children between the ages of 2 and 6, according to the NRC.

The system of early-childhood education in the United States is a "loosely sewn-together patchwork" of programs and services, as the report describes it. About 60 percent of preschool-age children are in "center-based" care, including services run through the federal Head Start program; roughly 21 percent receive some sort of home-based care; and about 20 percent have no formal child-care arrangements, according to the NRC report.

In addition to the Head Start program, which serves an estimated 908,000 students, many children in center-based care are enrolled in state-funded preschool, as the report points out. A number of states have moved to fund preschool programs for low-income families in recent years.

It follows that bringing about the changes in preschool teachers' training and professional development, Mr. Cross said, would likely require action from several players, including federal officials who administer Head Start, professional associations, and state licensing programs.

"It's a complex set of actors who would have to implement this," Mr. Cross said.

Whole Numbers, Geometry

The report recommends that providers of early-childhood education revise their math curricula, based partly on research on children's cognitive development. States should overhaul their standards and guidelines to reflect that research, and so should publishers, the authors say.

But the report also goes further, calling for early-childhood programs to focus on developing students' skills in a number of specific areas of math, which the authors see as crucial. Those topics include whole numbers, operations, geometry, and measurement.

In order to give early-childhood providers direction, the report's authors felt "we couldn't be too abstract," Mr. Cross explained. The report explores strategies for exploring that material in an age-appropriate way.

The authors also call for new course requirements for early-childhood teachers, with a focus on crucial math content, and on honing teachers' ability to deliver math instruction in different settings—to individual students, for instance, and to large and small groups of them. It also calls for new professional-development efforts, to help teachers already working in preschools.

Parents can also be encouraged to promote early math learning, the report says. Early-childhood providers can do more to provide guidance to families working with children at home; there also needs to be an expansion of informal math instruction through media and technology, the authors say.

Christina Satkowski, a program associate in education policy at the New America Foundation, a nonpartisan think tank in Washington, said interest in promoting more focused, early-childhood math instruction has received considerable attention from state officials, academic researchers, and others in recent years.

An important, next step is to provide stronger links between early-childhood math content and later grades, she argued.

"At the moment, many pre-K and early-childhood programs are disconnected from the K-12 system," Ms. Satkowski said in an e-mail. "This report emphasizes the need to create a seamless pre-K to 3rd grade continuum of math learning."

Working Math Into Play

The National Research Council, headquartered in Washington, is one of several nonprofit institutions charged with providing advice to Congress, as part of the National Academies. The early-childhood study received funding from the U.S. Department of Health and Human Service's Office of Head Start; the agency's Office of Planning Research and Evaluation; and the Ewing Marion Kauffman Foundation, which has provided funding for coverage of math and science issues at *Education Week*.

Ms. Satkowski said she believed the report could broaden understanding of how many different routes into math are available to teachers and parents.

"[E]arly math instruction doesn't have to be flashcards and worksheets," Ms. Satkowski explained. "A good pre-K or kindergarten teacher knows how to effectively integrate math into child-initiated play activities with questions about the number of rocks in their pail, the relative size of the two spiders they drew," and other means.

Published February 11, 2009, in Education Week

Kiddie Algebra

By Sean Cavanagh

Melissa Romano grew up attending school in classrooms that were quiet and orderly. And she liked it that way.

Today, as a 2nd grade teacher, Ms. Romano has learned to tolerate and even encourage more spirited discussion among her pupils, in the hope of cultivating their mathematical skills and, specifically, their algebraic thinking.

As educators and policymakers search for ways to prepare students for the rigors of algebra, Ms. Romano, at Broadwater Elementary School, and other teachers in the Helena, Mont., school system are starting early. They are among the teachers in a number of schools who are attempting to nurture students' algebraic-reasoning ability, as well as their basic number skills, in early elementary school, rather than waiting until middle or early high school.

To accomplish that aim, Ms. Romano says, it's not enough that she simply present pupils with a problem, collect their answers, correct their mistakes, and move on.

She takes relatively simple problems, then expands them, integrating algebraic thinking along the way. She changes the conditions and calls for class discussions. And she asks individual children to explain aloud: How do you know that?

As that give and take unfolds in class, "they're talking," Ms. Romano said, and "it's loud."

That process was "a huge, huge change for me," said the educator, who began using the algebraic reasoning and number-skill model in 2005. "The first two years were a big learning curve on my part."

When she was in elementary school herself, teachers gave her a math problem "and let me work on it," she said. "And I didn't understand half the math."

Ms. Romano and her colleagues in the 8,000-student Helena school district began to rethink math instruction, and the connection between basic arithmetic and algebra, four years ago, when they attended an institute offered by the Northwest Regional Educational Laboratory, or NWREL, a nonprofit research and evaluation organization in Portland, Ore.

Young, But Skilled

Those sessions focused on improving math instruction in the early grades. They placed a heavy emphasis on the principles of "cognitively guided instruction," an influential approach to math teaching and professional development first developed in the 1980s by Thomas P. Carpenter and other researchers at the University of Wisconsin-Madison.

A core idea of cognitively guided instruction is that young children arrive at school with a surprisingly strong set of intuitive math skills in areas such as understanding numbers and problem-solving. Teachers who understand those skills, and how students' math knowledge develops, can greatly improve their instruction, proponents of the methodology say.

Rather than emphasizing drill and procedure, cognitively guided instruction encourages teachers to nurture students' broader understanding of the relationships between numbers, patterns, and the fact that symbols can be used to represent numbers—skills that prove essential in algebra.

Long-Term Payoff

Education policymakers at all levels are grappling with the question of why students have difficulty in algebra and what can be done to help them. They reason that students who overcome challenges and complete introductory algebra, or Algebra 1, relatively early in school have a jump on advanced math and, presumably, a broader array of skills they will need in college and in the job market.

That rationale has led two states, California and Minnesota, to phase in requirements that students take Algebra 1 in 8th, rather than 9th grade, though the California measure has been held up in court. Many districts, meanwhile, are scrambling to improve teacher training in algebra and create intervention programs for students who cannot keep up.

Such struggles can be traced in part to schools' narrow conception of algebra, Mr. Carpenter said. Many teachers present arithmetic as a tool for "getting answers" and, separately, algebra as a more complicated study of relationships between numbers. A better approach, he said, is to zero in on the "big ideas" in arithmetic that will help students conquer algebra down the road.

"If you learn these big ideas early, there's a lot less to learn" later in algebra courses, Mr. Carpenter said. "Learning with understanding pays off in the short run, and it pays off in the long run."

If students, by contrast, approach math only by memorizing steps and procedures, he argues, their instruction leads to misconceptions that haunt them when they reach a full-fledged algebra course.

One common misconception Mr. Carpenter often cites involves the "equals" sign. Many students are mistakenly taught to regard the equals sign as signifying "the answer comes next," as in $8 + 4 = \_\_$.

But that's a mistaken belief, which is compounded when students reach algebra, where variables such as x and y can appear on both sides of the equation. The equals sign, in fact, connotes a relationship between numbers—that both sides of the equation are of equal value, or in balance. Yet for many students, Mr. Carpenter said, "the misconception continues all the way through algebra."

Linda Griffin, the director of the mathematics education unit at the Center for Classroom Teaching and Learning at NWREL, has led institutes in which she introduced teachers to principles of cognitively guided instruction, or CGI. Her organization has trained about 700 teachers in algebraic reasoning and number sense since 2004, typically over four or five days. NWREL also encourages districts to arrange for mentors and coaches to provide on-site support in those methods.

The idea of building algebraic reasoning in the elementary grades is a major departure for many teachers, Ms. Griffin said. Many were taught through their own experiences in school, and their professional coursework, to emphasize procedural knowledge, as opposed to "making sense of mathematics," she said.

Ms. Griffin and others who promote cgi strategies emphasize that they are not attempting to "teach algebra" to elementary school students in the strictest sense, so much as to

"algebra-fy' early-grades math in ways that carry forward.

Schools tend to "act like algebra's a whole new world," Ms. Griffin said. "Done well, it shouldn't be that way."

Tutoring Parents, Too

Ms. Romano tries to make the shift from arithmetic to algebra in subtle ways.

During one recent class, she gave her 2nd graders a problem about geese flying in a V formation. She used flocks of different sizes—three geese, five geese, seven geese. If the geese fly in a perfect V, she asked them, how many end up flying on each side?

Over the course of the class period, the pupils learned that with odd-numbered flocks, they could solve the problem by dividing the total number of geese by two, and subtracting one, for the lead goose. Ms. Romano moved on to ever-larger numbers: 49, 103. Eventually, she and the children worked out a formula they could use to solve the problem:

$$\frac{X - 1}{2}$$

Some students ended up making calculations into the hundreds. When others struggled, Ms. Romano encouraged them to draw pictures to illustrate their thinking. All told, the teacher spent 60 minutes working on variations of that single problem.

As Ms. Romano has been forced to change the way she thinks about math, she's asked parents at her school to adjust their way of thinking, too.

Some mothers and fathers, when they see their children's math homework, are eager to jump in and provide the answers for them. Ms. Romano urges them to hold back, and let children sort through problems and provide explanations on their own.

Just because pupils can spit out an answer, that doesn't mean they understand what they're doing, the teacher tells parents. When parents understand the process, she said, "they are amazed at what their kids can do."

Talking It Over

The principles used in cognitively guided instruction have played a significant role in shaping curriculum and the overall thinking about children's math skills in the early grades, said Douglas H. Clements, a professor of learning and instruction at the State University of New York at Buffalo.

Mr. Clements has developed an early-grades curriculum that builds math skills through games and other means—work that is based on research about how young children learn math tasks. The scholar, who says his own work has been shaped by principles of CGI, served on the National Mathematical Advisory Panel, a White House-commissioned group that last year issued recommendations on how to prepare students for introductory algebra.

While Mr. Clements supports having students think and talk through math problems, he also says teachers face a challenge in knowing when they have to step in and correct children when they make clear mistakes, so that students are not led astray mathematically.

"You can get so caught up in the talk, talk, talking," Mr. Clements said. "Sometimes, a teacher has to say, 'That's wrong.' " Teachers' time in class in limited, he noted. "You've got to use it for students' advantage."

Marla Ernst, an elementary teacher in Oregon's Lebanon Community School District who uses the algebraic-reasoning strategies discussed by NWREL, tries to correct students' errors in ways that encourage further discussion. She will ask them to explain a correct answer and diagnose where a wrong answer went awry.

"We don't leave a lesson until it's clear," Ms. Ernst said. "Math is about finding a right answer, but it's also about a process. You don't want to lose either part."

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Stereotype of Mathematical Inferiority Still Plagues Girls

Recent studies find females have caught up with the other gender.

By Sean Cavanagh

Educators and advocates have been pointing to the data and trying to get the word out for years: Girls perform as well as boys in mathematics. A recent study, which shows matching test scores in that subject between the sexes, appears to bolster the argument.

But even if the latest research helps shape public opinion on gender issues, school officials still face a major task in overcoming the stereotypes held by parents, teachers, and even girls themselves that boys are more suited to math-heavy studies and professions, particularly in such areas as engineering and physics, observers say.

The recent study, conducted by researchers at the University of Wisconsin-Madison and the University of California, Berkeley, is generally consistent with research dating to the 1990s showing both genders performing at roughly the same level in math. In contrast to some past findings, however, it shows males having no advantage over females in high school in that subject. Over the past few decades, young women have made strides in taking an increasing number of advanced math and science courses in high school, overcoming a deficit that some had cited as an explanation for higher male scores on standardized tests, the authors say.

Despite that progress, researchers say there is ample evidence that educators and policymakers should still be concerned about the waning of girls' interest in certain math-related subjects as they move through the pipeline. The consequences of those trends are reflected in the shortage of women in the highest levels of certain science, technology, engineering, and math, or STEM-related fields.

"We have to get the word out to parents and teachers," said Janet S. Hyde, a professor of psychology and women's studies at the University of Wisconsin and the study's lead author. "Stereotypes can still have an influence, as girls get on the math and science track. They're rarer today, but they still happen."

No Problem-Solving?

Her study, published in the July issue of the journal *Science*, examines male and female students' math scores on tests used by 10 states: California, Connecticut, Indiana, Kentucky, Minnesota, Missouri, New Jersey, New Mexico, West Virginia, and Wyoming, representing a testing population of more than 7 million students. The results showed boys and girls performing at very similar levels across grades, even at upper grades, the authors noted.

The study explores another major issue: whether there are gender differences among the highest-performing students in math. The researchers were able to examine results from a single state, Minnesota, and found that among white students, high-performing males outperformed females in that category by a small margin. But those scores were reversed among Asian-Americans in the very highest-scoring category, with females topping male scores. Ms. Hyde said those results suggest that cultural differences between demographic groups could explain some of the previously documented gaps between high-achieving males and females.

Overall, differences in math performance are "insufficient to explain lopsided gender patterns in participation in some STEM fields," the study concludes.

The researchers also sought to probe whether boys showed stronger ability in performing complex problem-solving tasks in math, as has been demonstrated in some earlier scholarship. But they were unexpectedly foiled in that task. Most of the state tests studied had no items requiring those complex skills—despite their importance in STEM professions, Ms. Hyde said.

The public and policymakers often mistakenly assume that attracting females, and retaining them, across all areas of math and science is a problem, said Jacquelynne S. Eccles, a professor of psychology, women's studies, and education at the University of Michigan in Ann Arbor, when in fact, that shortage is most pronounced in certain subjects, such

ETHNIC GROUP	SCORING ABOVE 95th PERCENTILE			SCORING ABOVE 99th PERCENTILE		
	Female	Male	Male-to-Female Ratio	Female	Male	Male-to-Female Ratio
Asian/Pacific Islander (n=219)	5.71%	6.27%	1.09-to-1	1.37%	1.25%	0.91-to-1
White (n=3473)	5.38	7.80	1.45-to-1	0.90	1.85	2.06-to-1

NOTE: Too few students from other ethnic groups scored at these levels to produce statistics for this table.
SOURCE: "Gender Similarities Characterize Math Performance," *Science* magazine, July 2008

View From the Top

A recent study found that while high-performing white boys in Minnesota outperformed their female peers in 11th grade, that gender gap was not pronounced among Asian-American students.

as engineering and physics. Many females avoid those areas not because of lack of academic skill, but because they see those professions as male-dominated and incompatible with their interests, which could include raising a family, she asserted.

"It's not that they're not engineers because they don't want to take math," Ms. Eccles said. "They're not taking math because they don't want to be engineers. You have to change their view of engineers."

Ms. Eccles' view appears to be borne out in the statistics. On one prominent measure of academic skill, the National Assessment of Educational Progress, males outscored females slightly in math at ages 9, 13, and 17, according to long-term-trend results, though that gap has declined over the past 30 years in the oldest age group.

Females today complete advanced math courses at about equal rates as males, according to a 2008 federal report. They also earn more bachelor's degrees than males in certain science fields, such as biological sciences and chemistry, it found.

But males, the report said, continue to dominate in engineering, computer sciences, and physics degrees, subjects often cited by business and political leaders as crucial to the nation's economic health and technological innovation. In not drawing more females into math and science, the country is squandering human capital, the thinking goes.

Careers Into Classroom

Girls would benefit from public-information campaigns and high school counseling that make it clear that women can thrive in science and engineering fields, Ms. Eccles argued. Schools and colleges can also do more to encourage women to persevere in math by encouraging females to work together and help each other in those classes, said Chandra Muller, a professor of sociology at the University of Texas at Austin. Ms. Muller is studying male and female students' transition to college, and their interests in math and science studies, under a grant from the National Science Foundation.

Female students in high school and college tend to benefit from "having enough girls around them who are doing well" in math, Ms. Muller said. Such strategies move "beyond tokenism" in encouraging girls and "shape the climate" of the classroom, she said.

Still, it's easy for females to feel out of place in school and college math classes, said Dara Shifrer, a graduate student who works with Ms. Muller. Ms. Shifrer says she was encouraged to take math seriously by her father, an engineer. When she reached college, she majored in math, though she was dismayed that so few females were in her classes. She had trouble envisioning what math-related careers were available to her after college, and the ones she heard about didn't seem appealing.

After college, Ms. Shifrer worked in human resources, then spent four years as a middle school math teacher. She says she tried to keep girls in her classroom engaged in the subject by calling on them regularly. Schools could do more to stoke girls' math interests by talking up the professional options available to them, she said.

"It's important to bring careers into the classroom. That's not happening," Ms. Shifrer said. "Kids still don't see how [math] is valuable."

She remembers her students being strongly influenced by their parents' attitudes toward math. A recent study found that fathers, in particular, exert a strong influence on whether daughters become keen on math, and that parents tend to exhort boys more in that subject. *(See Education Week, Oct. 24, 2007.)*

The question of whether males and females have different ability in math and science emerged in force in 2005, when then-Harvard University President Lawrence H. Summers speculated that differences in "intrinsic aptitude" between men and women, particularly at the upper levels of performance, could explain the dearth of females in tenured postsecondary jobs in science and engineering.

Ms. Muller and others say where differences in test results exist, the data also show that males tend to represent a larger share of both the very high and very low performers than do females in math.

Finding Value in Study

The recent study should compel policymakers to focus on motivating females of all ability levels to take math seriously, the Texas researcher said.

"Yes, girls are making inroads," she said. "But there are a lot of things that go into choosing a career other than [high] test scores. ... We should still be concerned about girls. There's huge attrition among girls throughout the pipeline."

Coverage of mathematics, science, and technology education is supported by a grant from the Ewing Marion Kauffman Foundation at www.kauffman.org.

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Panel Calls for Systematic, Basic Approach to Math

Federal advisory group's proposals may reignite debate on 'broken' content and instruction

By Sean Cavanagh

The influence of a federal report calling for a more orderly approach to teaching mathematics in the early grades will hinge largely on whether its message is accepted by the nation's diverse and often fiercely divided math community, members of the panel that crafted it acknowledge.

Released this week, the report of the National Mathematics Advisory Panel recommends that schools present elementary and middle school math in a better-defined manner, in contrast to the jumble of strategies now used in states and school districts.

"The delivery system in mathematics education—the system that translates mathematical knowledge into value and ability for the next generation—is broken and must be fixed," it says. "This is not a conclusion about any single element of the system. It is about how the many parts do not now work together to achieve a result worthy of this country's values and ambitions."

Initial reaction to the report, "Foundations for Success," was mixed.

Andy Isaacs, the director of the most recent edition of Everyday Mathematics, one of the nation's most widely used elementary school textbook series, said there was a "tremendous amount" of the report that made sense to him.

But Mr. Isaacs also said he was worried that the document's call for a strong refocusing on arithmetic and math procedures would discourage the use of other effective classroom methods.

"You could read it as really wanting to narrow the school curriculum down to core arithmetic," said Mr. Isaacs, who is based at the University of Chicago. "In education, we're always overcorrecting—going from one extreme to another."

Nearly two years in the making, the report went

through 90 drafts, with its members wrestling over major recommendations and individual words and phrases. It was approved unanimously at the panel's final meeting, held March 13 at Longfellow Middle School here in a suburb of the nation's capital.

'First Things First'

The 90-page document calls for the math curriculum to be streamlined in pre-K-8, a strategy it calls putting "first things first." Students need to be grounded in both the effortless, automatic recall of simple procedures and in the acquisition of broader problem-solving skills. Too often, those skills are wrongly presented as incompatible, the report says.

At various points, the authors also allude to the enduring philosophical battles over how to teach the subject—commonly referred to as "the math wars." Those disputes tend to pit those who argue that students should be grounded more firmly in simple math procedures against others who advocate a more conceptual approach to teaching and learning.

The arguments, the panelists believe, miss the point.

"Debates regarding the relative importance of these aspects of mathematical knowledge are misguided," the report says. "These capabilities are mutually supportive, each facilitating the learning of the other."

But the authors also identify a clear path to prepare students for introductory algebra and advanced math—the central charge given to the panel. Students should become proficient with whole numbers, fractions, and aspects of geometry and measurement in order to steel themselves for algebra, typically taught in the 8th or 9th grade, the report says. State tests, teacher education programs, and textbooks should be tailored to promote those skills; so should the National Assessment of Educational Progress, known as "the nation's report card," it says.

Identifying Skills

At their final meeting, a number of panelists urged math teachers and academic scholars, as well as influential professional associations, to help them promote the report's findings—even if some recommendations disappoint them.

Organizations such as the 100,000-member National Council of Teachers of Mathematics—whose president, Francis M. "Skip Fennell, served on the panel—will play a strong role in determining whether its ideas are translated for K-12 teachers, panel Chairman Larry R. Faulkner said after the meeting.

"Responsibility for education in this country is so decentralized," said Mr. Faulkner, a former president of the University of Texas at Austin. Math organizations and associations are often "the best way to connect" to teachers and policymakers, he said.

President Bush signed an executive order creating the panel in April 2006. The group, which has 19 voting and five nonvoting members, was charged with identifying the math skills students need to ready themselves for introductory algebra and higher-level math, based on the "best available scientific evidence." Educators generally regard algebra as a crucial first step in preparing students for advanced math.

The panel's report repeatedly calls for students to be able to recall math procedures, such as basic addition, subtraction, multiplication, and division, quickly and effortlessly. It also says that students' difficulty with fractions is "pervasive" and a "major obstacle" to learning algebra.

Emphasis Debated

Being able to recall basic number facts automatically reduces the strain on students when they encounter more-demanding tasks in algebra, said panelist Vern Williams, who teaches that subject at Longfellow Middle School.

"If your mental energy is consumed figuring out what six times nine is, when that should have been covered three or four years ago, how are you going to conceptualize about math?" Mr. Williams said after the meeting.

But Steven Rasmussen, the publisher of Key Curriculum Press, a producer of math textbooks and software based in Emeryville, Calif., said the report's heavy emphasis on basic arithmetic and fractions—which he regards as important—left out other topics that help prepare students for high school math.

Exposure to basic elements of data analysis, statistics, and applied math, engage students and allow them to relate math to workforce skills, he said.

"This report is biased in favor of teaching arithmetic and not [modern] mathematics," Mr. Rasmussen said, "and it's biased in favor of procedures and not applied skill."

In seeking to base its recommendations on the kind of evidence specified by the White House order, the panel ranked studies of math programs and strategies in categories ranging from "strong evidence" to "inconsistent" to "weak," depending on the methodology the studies used.

Mr. Rasmussen and Jere Confrey, a professor of math education at North Carolina State University in Raleigh, said the panel's criteria were too restrictive, however.

Case studies and other research that do not meet the "scientific evidence" standards used by the panel could provide valuable information on the true impact of math programs and interventions in the classroom, Ms. Confrey argued. The panel gives "short shrift to the need for multiple methods of research," she wrote.

But panel members also discovered that some areas related to math education, such as cognitive studies of how children learn, have produced much more high-quality research than others, such as how to prepare math educators and give them ongoing professional development, said Mr. Faulkner, the chairman.

"We're going to have to learn more about what makes a good teacher and how to instill" those abilities, said Mr. Faulkner. "Very little is known about these things," he added, "surprisingly little, given [their] importance."

"The 90-page document calls for the math curriculum to be streamlined in pre-K-8, a strategy it calls putting 'first things first.' Students need to be grounded in both the effortless, automatic recall of simple procedures and in the acquisition of broader problem-solving skills. Too often, those skills are wrongly presented as incompatible, the report says."

Bush administration officials have compared the math advisory group to the National Reading Panel, which in 2000 produced a report that influenced instruction in that subject. The reading panel, originally authorized by Congress in 1997, during the Clinton administration, recommended that explicit phonics and the direct teaching of other basic skills be a core part of elementary reading instruction. Phonics connects sounds to the letters of the alphabet.

Some researchers and educators complained that the reading panel focused on a small body of research and a narrow range of topics for its report. Consequently, they say, policies and commercial products have underemphasized several components they view as important for students' reading achievement, such as writing instruction and background knowledge.

The reading panel's recommendations shaped the grant requirements under the $1 billion-a-year Reading First program. Congress recently slashed the program's budget to $393 million for fiscal 2008, amid complaints about favoritism and conflicts of interest in its implementation.

NCTM Reaction

The impact of the math panel's report is unclear at this point. No single federal program in math compares to Reading First in influence or level of funding. A federal report released last year identified 105 separate programs, which spend a total of $3 billion on education in the so-called STEM subjects—science, technology, engineering, and math—across several agencies, about $570 million at the K-12 level.

U.S. Secretary of Education Margaret Spellings told reporters after the meeting that she would ask other agencies to consider using the panel's recommendations to shape grant awards and other policies. While Mr. Bush, who commissioned the report, will leave office in less than a year, the report will shape education policy long after that, she predicted.

"This really transcends politics or administrations," Ms. Spellings said.

The math panel included a number of cognitive psychologists, researchers, and college faculty members who have studied math issues. Mr. Fennell, the NCTM president and panel member, said he hoped the document would encourage a nationwide push for "greater coherence" in math instruction.

The math teachers' council, based in Reston, Va., has angered some parents and mathematicians who believe it has pushed a style of math focused too much on conceptual learning and not enough on automatic recall of number facts. But the organization also won praise from its critics more recently, with its publication in 2006 of "Curriculum Focal Points," a document aimed at streamlining the list of key math topics in prekindergarten through 8th grade, which NCTM has been promoting nationwide.

James M. Rubillo, the NCTM's executive director, who attended the national math panel's final meeting, said early drafts of the report had drawn mixed reactions from his organization's members. He said he was pleased with the report's use of "Focal Points" as a reference guide for how math should be taught at early grades.

The report brings "unprecedented focus" to math instruction, the NCTM said in a statement, and "addresses many of the actions needed" to improve math education.

But Mr. Rubillo said the report's language about calculators was not firmly grounded in research. The report, citing a limited number of studies, found that those devices have "limited or no impact" on certain math skills. The NCTM has been generally supportive of calculators' role in the classroom.

While many panel recommendations "are supported by high-quality research, others extend beyond the report's reach," the NCTM said in a statement. Many of the issues raised in the report, it said, still "require extensive and ongoing research in order to identify approaches that can be broadly applied."

Core Recommendations

THE DEFINITION OF ALGEBRA

The panel developed a clear concept of "school algebra" courses, which the report says should include coverage of: symbols and expressions; linear equations; quadratic equations, functions, algebra of polynomials; and combinatorics and finite probability. These should be the focus of state curriculum frameworks, algebra courses, textbooks, and end-of-course exams.

STRUGGLES WITH FRACTIONS

"A major goal for K-8 mathematics education should be proficiency with fractions (including decimals, percents, and negative fractions), for such proficiency is foundational for algebra and, at the present time, seems to be severely underdeveloped."

MATH WARS

"To prepare students for algebra, the curriculum must simultaneously develop conceptual understanding, computational fluency, and problem-solving skills. Debates regarding the relative importance of these aspects of mathematical knowledge are misguided. These capabilities are mutually supportive, each facilitating the learning of the others."

HELPING DISADVANTAGED STUDENTS

"Children's goals and beliefs about learning are related to their mathematics performance. Experimental studies have demonstrated that changing children's beliefs from a focus on ability to a focus on effort increases their engagement in mathematics learning, which in turn improves mathematics outcomes. [Research shows] that the engagement and sense of efficacy of African-American and Hispanic students in mathematical learning contexts tend to be lower than that of white and Asian students, but also that it can be significantly increased.

TEACHER- VS. STUDENT-CENTERED INSTRUCTION

"All-encompassing recommendations that instruction should be entirely 'child-centered' or 'teacher-directed' are not supported by research…High-quality research does not support the exclusive use of either approach."

'EXPLICIT' INSTRUCTION

"Explicit instruction with students who have mathematical difficulties has shown consistently positive effects on performance with word problems and computation." The panel defines that term to mean "that teachers provide clear models for solving a problem type using an array of examples, students receive extensive practice in use of newly learned strategies and skills, students are provided with opportunities to think aloud [talking through decisions they make and steps they take], and students are provided with extensive feedback."

WHAT RESEARCH SAYS (OR DOES NOT SAY)

"As in all fields of education, the large quantity of studies … on important topics in mathematics education is reduced appreciably once contemporary criteria for rigor and generalizability are applied." Government agencies should increase their support for research on math education, the report states, and emphasize "stringent methodological criteria," such as randomized controlled designs and methodologically rigorous quasi-experimental studies.

SOURCE: National Mathematics Advisory Panel

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CHAT HIGHLIGHTS

MATH STAGNATION in High School

On August 27, 2009, two experts answered readers' questions on why students' math scores are stagnating in the upper grades, whether there have been improvements to early-grades math curriculum or teaching that are not being carried through to older students, and whether students' difficulties with certain topics, such as algebra, are standing in their way. The following is an excerpt from that chat. To read the transcript in full, visit http://www.edweek.org/ew/events/chats/2009/08/27/index.html

HENRY S. KEPNER was the president of the National Council of Teachers of Mathematics at the time of the chat. SUSAN K. EDDINS is an educational consultant and former teacher with the Illinois Mathematics and Science Academy.

Q I have a B.S. in Mathematics, but not in math education and am still heavily in debt with student loans. I have a couple of years' experience teaching math at a local community college as an adjunct on an emergency basis. I understand that there is supposed to be a shortage of math/science teachers in various parts of the country. Are there schools or other institutions which would help me to obtain the requisite certification to teach mathematics?

SUE EDDINS: Several years ago I taught in a program to provide alternative certification for folks in your position or those who wished to change careers but had a good math/science background. Many colleges and universities offer such a program so I would encourage you to look in your area for that sort of thing. As a second comment, I would say that I preferred folks who were going to teach high school to have a math degree rather than one in education.

Q The National Math Panel spoke to a need to focus on proficiency in K-8 for fractions, whole numbers, measurement and some aspects of geometry and measurement. Which publishing companies have responded the best to this recommendation? How will the national math standards support this recommendation?

HENRY KEPNER: The National Math Panel recommendation is well-known and highlighted in most programs. I would make the case that the challenge is on helping students understand the conceptual reasons why fractions work that way along with estimation skills. Unfortunately, too often stress in the classroom may be on formula and skill manipulation without connections to meaning and sense of results.

Q ACT's "The Forgotten Middle" makes the claim that "Eighth-grade students' achievement has a larger impact on their readiness for college by the end of high school than anything that happens academically in today's high schools." What does this tell us about what to do with high school students who enter behind in math? And do you believe that students' fates are basically sealed by eighth grade?

SUE EDDINS: It seems to me that at least part of the problem is that many capable students are able to be relatively successful in math through the early grades by learning discrete facts. Moving into middle school, learning conceptually becomes increasingly necessary and many students tend to fall apart at that level. Nothing is "sealed" about the fate of a student, but unlearning habits of how one learns provide an additional challenge.

Q I'd like to explore the algebra problem. Do kids crash & burn in algebra because of the way the subject is defined, the way it is taught, or because they don't have the prerequisites?

HENRY KEPNER: All of your observations are part of the challenges. It takes student exposure and discussion in getting comfortable with variables having the same meaning as specific numbers over over a student's life before algebra. E.g., 3 + 5 is a number, just as 8. It is puzzling for students to accept "m + n" as a final result.

Also, there is often a serious gap between solving equations and comfort in creating equations that represent a phenomenon in society (math modeling). I personally would hope that students spend as much time translating context settings and tables of values into mathematical expressions, equations or functions as practicing the skill of solving.

SUE EDDINS: Again, I think that the answer is that the way many students learn how to do math is some rote formula that is not digested by them, but repeated from being shown "how," not "why" to do something. Procedures learned that way are easily forgotten - I think about all the dates I knew at one time to get an A in history! We need to have students learn the foundational ideas as concepts and understand where the procedures come from if they are to transfer to higher level content.

Q I remember elementary school math being much more 'hands-on' with items being physically counted/weighed/measured. In high school, all of the hands-on instrumentation (Geiger counters, volt/ammeters, pH meters, etc.) was conducted in natural/physical sciences classes, but math class was limited to textbook and lecture learning. Might this difference in teaching style result in a reduction of learning?

SUE EDDINS: I think that having more "hands-on" math in high schools is an excellent idea, and I agree that it would be great to have more high school teachers comfortable with that. We do need to remember, however, that moving into conceptual understanding is key in order to master high school content so conclusions need to be made after the hands-on experience. Also, the instruments can change. Graphing calculators, while not exactly hands-on, have provided an invaluable visual tool for math exploration.

Q Should U.S. schools be focused on adding more high school math options for students? And how realistic is it to think that U.S. high schools can offer these alternatives?

SUE EDDINS: I think [adding options] is an excellent idea. With the new common standards that are about to come out from NGA and CCSSO, there will be a more common definition of what is a baseline for all students by the end of high school. Once students have achieved that level, many will have a year or two to take other courses and right now AP Statistics and STEM courses are about the only alternatives. Other courses at a comparable level would be wonderful, letting students see how math is used in art, music, finance, and so on.

Q Wouldn't adding more course options in high school create a financial/staffing burden on schools? And can you suggest any way around that?

HENRY KEPNER: Actually, the expanded courses may only be a burden in that more students would stay in mathematics longer - based on more motivation/interest, and possible success.

Q As I see it, the more pressure that is put on standardized test scores, the [more difficult it becomes to give children a sound foundation in math]. Could you please comment?

SUE EDDINS: I tend to agree in general that we are losing the goal of real learning to the goal of "getting through." I mentioned this earlier, and I think it applies even more broadly than in the testing, but it certainly applies there as well. They are learning how to do well at the moment and sometimes at least sacrificing the learning that will lead to understanding in the future.

Q Would we be in a rush to abandon trigonometry and calculus and such for most all of our students if these courses were taught in an active, investigative, applied (design, build, explain) mode that would likely make them more appealing to more students? Otherwise, one might wonder if we're not erecting filters... sealing fates, perhaps.

SUE EDDINS: I don't think that we would be erecting filters for students by not giving them calculus provided we have given them a solid base through the level described by Achieve's ADP document or the about-to-be-released Common Core Standards. Some student may just want to go another direction. I do think we do a disservice to students who complete that work prior to 12th grade when we offer no attractive alternatives to the STEM track. We want students to remain in math all through high school - there is strong evidence that this in and of itself has a tremendous impact on student success. The calculus is not the only possible valuable direction in my opinion.

HENRY KEPNER: For most college students, one can argue that there are more important mathematical topics to learn than calculus. It's a priority question for a student's time and energy. A societal question related to mathematics: for a person to be mathematically literate in our culture, how would we prioritize statistical decision-making and certain components of trig? I don't say make an all-or-nothing choice, but rather a reasoned decision.

I might note that the large number of newspaper journalists that I talk to all over the country about mathematics would have benefitted from more statistical reasoning than others.

Your point about "shutting doors" is a major concern, but mathematics is having a bigger and bigger foundation for use throughout disciplines - and they don't have the same foundational sets.

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COMMENTARY

Teaching Secrets: Making Math Meaningful for All

By Cossondra George

While it is considered unacceptable for the average person to lack basic reading and writing skills, people often brag about their inability to "do math." It is almost a badge of honor to be numerically challenged.

As classroom teachers, we must overcome this attitudinal acceptance of not being successful at math before we can create numerically literate students. We must learn to teach in ways that make mathematics accessible to every child and build our students' confidence in their capacity to master the knowledge and skills associated with our important—and intriguing!—content area.

Having taught 7th grade math for many years, I have discovered some keys to success with my students. These fundamental instructional strategies are easily adapted to any grade level math class.

Purchase a set of student whiteboards for your class. These boards are fantastic for many purposes. I like to use them when I am first introducing a concept to allow students the opportunity to write the steps or process as I am doing it, then practice on their own in a non-threatening environment. Even the most intimidated math-a-phobe seems less concerned about making mistakes when they are easily erased with a paper towel. I also use these boards when reviewing concepts before a quiz or test. Having students complete individual problems, then hold up their boards with answers circled simultaneously, quickly shows me where the misconceptions and allows me to quickly restructure our next step in the review.

Create real-life examples of concepts you are learning. Going beyond the typical 'story problems' included in most math textbook series, and generating your own meaningful examples of how topics relate to real life, helps students cement those concepts in their brains. For example, when we study inverse relationships in my classroom, not only do we plot the length and width of a rectangle with a given area (as suggested in the text), I create a group project where students look at earning a set amount of money from a given task. They graph the possibilities in large graph paper, write the equation for the inverse relationship, illustrate it and present it to the class as a group. Having this concrete real-life example gives them something to associate with this often difficult concept, making it "stickier" in their minds.

Use small groups and presentations where students teach each other as well as the entire class. The old adage that you learn something better when you teach it is certainly true in math class. By explaining a concept to another student, the presenter is forced to think more deeply about the process involved in the task at hand. Using large graph paper to create (and illustrate) graphs for a presentation is always a huge hit simply because of the social and artsy nature of making them. Students work together, learning from and with each other, both when they create the product and when they present it. These procedures engage students actively in the thinking process—the goal of every lesson.

Teach the power of "Is your answer logical?" When working out problems with students, look at the answer critically, asking probing questions to lead them to whether or not the answer makes sense in the context of the problem. Students too easily accept the answer in their calculator window just because the calculator said it was the answer. Walk them through logical and illogical answers, and how to hone in on the correct solution simply by eliminating possibilities. Use actual problems solved incorrectly on assignments or tests to have students analyze the process of making mistakes and how to identify where the solution went wrong.

Integrate technology to capture student interest. Many websites offer interactive math activities. One such site is the National Library of Virtual Manipulatives. This site organizes math activities by topic and grade level and offers many simple but engaging tools to explore concepts. Some of the activities lend themselves well to large group instruction, while others are wonderful for students to use individually. Other sites to consider are Interactive Mathematics Miscellany and Puzzles and Cool Math.

Encourage, require, demand re-do's. Having students rework problems they missed on both tests and daily assignments teaches perseverance. Over time this process will help students identify their mistakes more readily and strengthen their ability to think critically. Another strategy to encourage students to examine problems more closely is to give them the answer upfront and invite them to explain the solution by working backwards. The goal here is to go beyond the traditional teacher demonstrations of how to solve problems and have students learn to work independently, correct mistakes, and move on. Students become mathematical thinkers and build success.

The ultimate goal in each of these strategies is to develop students who enjoy the processes of math, learn to appreciate the complexities of the subject, and find ways to relate math to their everyday lives. Through this process, we can build a generation of adults who are comfortable with mathematics and confident in their numerical abilities.

Cossondra George is a veteran mathematics and special education teacher in Newberry, Michigan. She blogs about the teaching life at Middle School, Day by Day. Her 2008 essay, "Taming the Dragon of Classroom Chaos," continues to be one of the most popular Teaching Secrets articles in the Teacher archives.

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COMMENTARY

It's Not Just for Reading

How RTI can refocus math instruction on student learning

By Paul J. Riccomini

The field of education is going through pervasive changes regarding learner outcomes and accountability for all students. As a result, educators are focusing their efforts in a variety of areas. One area receiving enormous attention is response to intervention. Initially, the focus of RTI was directed at improving early literacy programs in an effort to reduce the number of students identified with specific learning disabilities. The RTI movement is now quickly expanding to mathematics.

Many definitions and descriptions of RTI exist, but for the purpose of this discussion, I define RTI as the general process by which educators (often a team) use objective student-performance data to determine when additional instruction and/or interventions are needed prior to any determination of a learning disability. RTI employs a series of instructional tiers with increasing instructional intensity. Within the RTI description, there are several main components, but one especially important component that must be properly addressed is the emphasis on classroom instruction, which includes both content and instructional approach. If instruction for struggling students is not carefully developed and planned, RTI efforts will likely have little positive effect on improving students learning of mathematics.

Refocusing the Debate

Much debate and energy has been spent regarding the "what" and "how" to teach mathematics in this country. Often intense, these debates revolve around content and method of instruction. Unfortunately, the debates among mathematics educators, mathematicians, researchers, and policymakers often have little to do with students. Instead, they are often about posturing to defend or advocate for a certain instructional philosophy. Although debate is healthy in any profession, the debate over what and how to teach mathematics has delayed true educational reform and negatively impacted many students' math experiences.

The use of an RTI math framework is gradually refocusing this debate back to the content and instructional needs of the students. RTI procedures require that instructional decisions be based on student-learning data, not philosophies or opinions. RTI is helping educators' efforts in determining what to teach and, more importantly, which instructional approach to follow. As RTI math initiatives continue to expand, however, teachers are often left to their own means to sort through the overwhelming volume of content and instructional recommendations for improving student learning, some of which may seem counterintuitive. Recently, there has been some movement to provide more guidance to educators on the most effective instructional approaches based on high-quality research.

In 2008, the National Mathematics Advisory Panel released a report to help guide math teachers to improve instruction within an RTI framework. The report addresses the age-old debate around teacher-led vs. student-centered instruction and denies the two are mutually exclusive. In fact, the NMAP report clearly states that research does not support a strict dichotomy. It recommends teachers use a balance of student-centered and teacher-led instruction, particularly in the case of low-achieving students, students at-risk for math failure, and students with disabilities. The NMAP panel recommendations can be used to bolster a RTI math program, particularly for students who are struggling.

Promoting Understanding

Based on the review of more than 16,000 research studies, the NMAP suggests five general recommendations to consider when designing instruction for struggling students within an RTI framework. First, teachers should use explicit methods of instruction on a regular basis. Second, teachers should teach students clear problem-solving methods and strategies. Third, teachers should use carefully sequenced examples to help struggling students facilitate important connections. Fourth, teachers should use concrete representations to promote the understanding of abstract representations in mathematics. Fifth, teachers must provide students with additional opportunities to think aloud. The panel's recommendations should form the foundation of RTI math instructional decisions.

As students progress through an RTI system,

RTI Math Instructional and Intervention Recommendations

Instructional Strategies:

– teacher-directed instruction
– direct instruction
– more models and demonstrations
– explicit problem- solving strategies
– focused instruction on deficit areas
– think-alouds
– corrective feedback

Intervention Strategies:

– small group (3-10 students)
– one-on-one tutoring
– guided practice
– independent practice
–classwide peer tutoring
– computer-assisted instruction

SOURCE: Response to Intervention Math (Corwin, 2010), by P.J. Riccomini & B.S. Witzel

teachers must carefully consider these five recommendations when developing and implementing instructional interventions. In fact, these recommendations must become more apparent in all instructional tiers, including Tier I, if positive effects are to be achieved. Additionally, it is important for teachers to recognize that students who are not struggling may require less teacher guidance than struggling students. At the same time, teachers must plan to enrich and accelerate more advanced students; their instructional needs must also be considered in the context of RTI.

The Ultimate Goal

Mathematical proficiency is the ultimate goal of mathematics instruction regardless of whether the teacher or the student is driving instruction. Depending on an educator's point of view, mathematical proficiency may emphasize concepts and problem-solving over procedures and computation. However, the NMAP describes effective mathematics programs that promote proficiency in the following areas: conceptual understanding, computational fluency, factual knowledge, and problem solving skills. It is important for teachers to recognize mathematical proficiency requires the seamless blend of each of these five areas outlined by the NMAP. And if students are lacking in any of the five areas, proficiency is not achieved.

With more and more focus placed on improved mathematical proficiency by students, it is imperative that the best available evidence,~~ n~~ot educational philosophies,~~ g~~uide the field. Basing instructional decisions on students' needs and high-quality research is especially important and relevant in the context of RTI. When students struggle in their learning of mathematics, time is at a premium and teachers must rely on effective and efficient instructional techniques.

As a researcher committed to helping improve math instruction, I wholeheartedly support and promote the use of research-validated best practices to the maximum degree possible. As a parent of two children in elementary school, I applaud the teachers who work tirelessly, often thanklessly, to implement evidence-supported mathematics practices every day in their classrooms. Thank you!

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http://www.educationaleffectiveness.org/conferences/2009/pages/abstracts/055_college.doc
Elaine M. Allensworth and Takako Nomi
Journal of Urban Education, March 2008

Focus in High School Mathematics: Reasoning and Sense Making

http://www.nctm.org/standards/content.aspx?id=23749
National Council of Teachers of Mathematics

Gender Similarities Characterize Math Performance

http://www.sciencemag.org/cgi/content/summary/sci;321/5888/494
Janet S. Hyde, Sara M. Lindberg, Marcia C. Linn, Amy B. Ellis, and Caroline C. WilliamsUniversity of Iowa,
Science, July 2008

Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity

http://www.nap.edu/catalog.php?record_id=12519
Christopher T. Cross, Taniesha A. Woods, and Heidi Schweingruber, Editors
Committee on Early Childhood Mathematics, National Research Council

The Misplaced Math Student: Lost in Eighth Grade Algebra

http://www.brookings.edu/reports/2008/0922_education_loveless.aspx
Brown Center on Education Policy at the Brookings Institution

National Mathematics Advisory Panel

http://www.ed.gov/about/bdscomm/list/mathpanel/index.html

Window of Opportunity? Adolescence, Music, and Algebra

http://jar.sagepub.com/content/25/4/557.abstract
Barbara H. Helmrich
Science, July 2010

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