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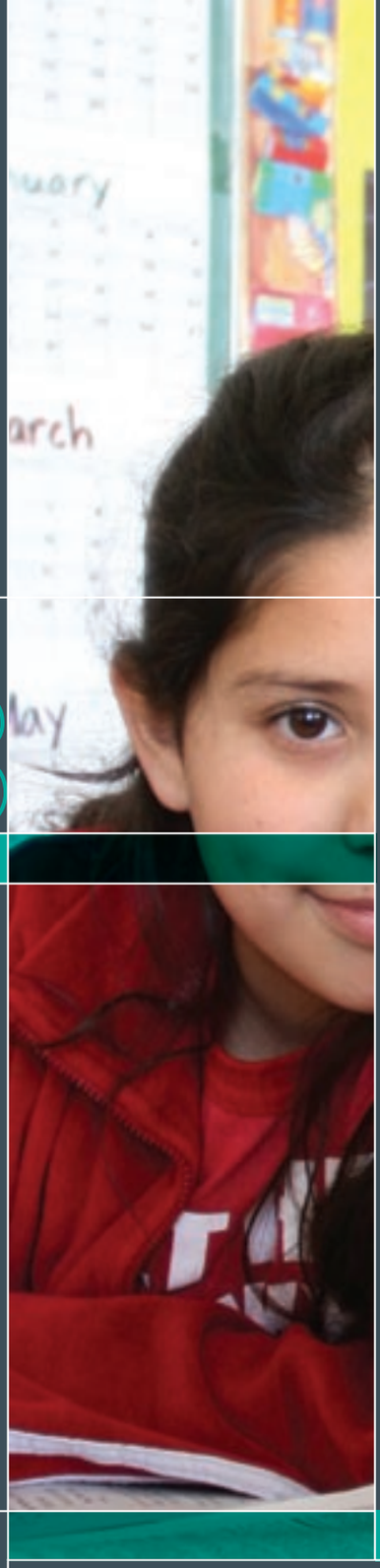

r&dalert

R&D Alert covers issues affecting schools, communities, and human development professionals throughout the United States. Current and previous issues are available at WestEd.org/R&DAlert. Your letters are welcomed. Please send comments to Noel White at nwhite@WestEd.org or by regular mail to: Noel White, WestEd, 730 Harrison Street, San Francisco, CA 94107-1242.

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MAKING THE MOST OF MISTAKES

Math Pathways and Pitfalls Improves Student Learning

>>> Learn from mistakes. That's good advice, whether coming from business gurus or seasoned parents. But it is advice rarely applied in the typical elementary mathematics lesson, where there is so much pressure to get the "right" answer that teachers usually avoid dwelling on students' errors. And according to research behind WestEd's Math Pathways and Pitfalls (MPP) initiative, this typical approach misses important opportunities for learning.

One of the most prevalent instructional approaches in U.S. mathematics classes, as documented by the Trends in International Mathematics and Science Study (TIMSS), consists of the teacher showing students how to find solutions to a few examples on the board. Students then work on their own to find solutions to similar examples. In this approach, teachers intentionally avoid common errors and misconceptions because they're concerned about causing students to remember the wrong solution process, notes Carne Barnett-Clarke, Senior Research Associate at WestEd and MPP principal investigator.

However, students' errors and misconceptions often persist. Even after a complete unit on decimals, for example, teachers may be surprised to find that many of their students still say that 0.7 + 0.5 = 0.12 (correct answer is 1.2).

PAGE 4

continued from previous page

Barnett-Clarke says such errors may be symptomatic of more significant weaknesses: perhaps an inability to recognize when a solution is unreasonable, or a failure to make sense of mathematical symbols.

In response to students' mistakes, most teachers show them more examples of correct solutions and then give the students more practice. But this approach does nothing to address the students' underlying conceptual understanding. Students may continue to look only at the surface features of the problems. They see a 7 and a 5 and a plus sign, for example, so they add the numbers to get 12, then put a decimal point in front.

Without any deeper understanding of the mathematical concepts and of the symbols used to represent the concepts, students will continue to think an incorrect solution makes perfect sense, even when it is pointed out as an error.

Mathematical concepts, misconceptions, and language

Research on MPP, a long-term WestEd initiative, has found that teachers can modify how they usually teach mathematics and significantly boost students' achievement. MPP provides teacher professional development and a series of classroom lessons for grades K—7 to teach students how to participate in high-level, productive discourse about complex mathematical concepts, including focusing explicitly on errors.

A sample of the Discussion Builders posters

> Teachers can modify how they and **significantly boost**

As students begin recognizing common pitfalls and misconceptions that can derail their reasoning, they are more likely to ask themselves, "Where can my thinking go wrong?" says Barnett-Clarke. "That means they are less likely to develop stubborn misconceptions or just fall into mistakes, especially when taking a test."

Barnett-Clarke says MPP shows students how to use the high-level, sophisticated, precise kind of "academic language" they need to talk about mathematics in a meaningful way. "It goes beyond just learning math vocabulary and symbols to being able to explain one's reasoning using mathematical syntax," she says. "It's knowing how to use 'if . . . then' statements, make conjectures and justifications, and offer arguments that support a way of solving a problem."

Benefits for English learners

While MPP's instructional practices have been found helpful to all students, its emphasis on the support of verbal and symbolic language is proving especially effective when it comes to boosting the math achievement of English learners.

Scaffolding mathematical discussions is a particularly important way to provide effective instruction for language minority students, says Alma Ramirez, WestEd Senior Research Associate who co-directs MPP with Barnett-Clarke. MPP lessons provide scaffolding through "attention to vocabulary, support for students' writing, the use of various modes of communication, and support for participation in academic discourse in mathematics." Each lesson, for example, begins with the introduction of important mathematical vocabulary and includes language acquisition strategies.

usually teach mathematics students' achievement.

MPP lessons give students practice presenting complete and coherent explanations of math problems, and help them become comfortable expanding upon, proving, or disproving mathematical ideas. Barnett-Clarke says that students who master these kinds of discussion skills "won't be thrown when they get to high school or college by a language that really sounds different to them."

Teachers can use MPP "Discussion Builders" posters (see sample on page 4) to give students examples of how to build on, analyze, and justify their ideas or the ideas of their classmates.

For example, prompts on the posters encourage students to present alternative ideas by stating, "I wonder what would happen if . . ." They can expand on a classmate's ideas with a statement that begins, "I'd like to add to _____'s idea." Or they can pose additional questions by asking, "Would that be true if . . . ?"

Barnett-Clarke says this kind of attention to language is rare, especially in math classes. Most people, including many teachers, erroneously think of math as language-free. "But elevating mathematical discourse by using academic language is a powerful way to gain information and understanding."

"This approach is particularly important," says Ramirez, "because much of the schooling for language minority students has excluded them from the academic discourse community of the classroom." Too often, she says, these students have been relegated to "watered-down, remedial" math lessons that included little talk, few representations, and minimal reading or writing about mathematics.

MPP, by contrast, provides language support aimed at helping all students develop a "robust understanding" of

PAGE 17

HELPING ENGLISH LEARNERS ACQUIRE THE LANGUAGE OF MATHEMATICS

>>> English learners face formidable challenges in the classroom. Besides learning to communicate with teachers and peers in conversational English, they also must grapple with the complexities of "academic language" in order to acquire new content knowledge. For the English learner in middle or high school, there's an added time pressure of having limited years left to catch up in English and learn the appropriate academic content.

Teachers are the key to helping students overcome these challenges. Yet, in mathematics (as in many subject areas), few teachers are well-prepared for the job. Most secondary math teachers lack explicit knowledge of how to help the English learners in their classes acquire academic language. And teachers who specialize in English as a Second Language (ESL teachers) rarely have a strong background in mathematics. Struggling to support these students, educators too often resort to simplifying the math content or language or both.

And that approach, says WestEd Research Associate Donna Gaarder, is dead wrong. "If an adolescent is in the process of acquiring English, she or he doesn't have as much time to close that gap as a first-grader. You need to *accelerate* learning instead of giving work that is not grade-level appropriate."

Her colleague, Theresa Hernandez-Heinz, agrees. "Sometimes the approach is to take children and teach them English and, meanwhile, give them very easy work [in the content areas]. Our approach is to say, 'No, give them the same challenging work as everyone else, but support them well so they can do it.'"

Quality Teaching for English Learners

Gaarder and Hernandez-Heinz design and deliver professional development as part of WestEd's Quality Teaching for English Learners (QTEL) project. QTEL's goal is to help teachers in several core disciplines engage middle and high school English learners in intellectually challenging tasks while providing a high level of support to help them succeed. Created in 1999 by Aída Walqui, Director of WestEd's Teacher Professional Development Program, QTEL

PAGE 8

Created in 1999 by **Aída Walqui** (left), Director of WestEd's Teacher Professional Development Program, QTEL offers intensive, institute-style professional development series for teachers and teacher leaders.

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offers intensive, institute-style professional development series for teachers and teacher leaders. And as teachers apply QTEL pedagogy in their classes, the project provides ongoing coaching from experts.

Gaarder and Hernandez-Heinz focus specifically on mathematics. In the past five years, the two estimate they have worked with over 900 secondary mathematics teachers in New York City, San Francisco, San Diego, and San Jose, California, among other cities. In the 2007—08 school year, the QTEL team is beginning additional work in Austin, Texas.

The language of mathematics

QTEL's approach, even in mathematics, is rooted in language. The focus is specifically on students' linguistic development, helping them learn to read, write, and discuss academic texts in challenging academic courses. Says Hernandez-Heinz, "Most people don't realize how language-dependent learning really is." This is especially true in mathematics, adds Gaarder. "Teachers often assume that mathematics is a universal language and that you don't need to pay attention to the learning of English."

Many students, even native English speakers, lack proficiency in the language of mathematics, says Gaarder. "Often a student will use gestures, disconnected words, and half-phrases to talk about mathematics. The role of the teacher is to pull that language out and model the kind of academic language students should be using." The goal, she explains, is to deepen students' understanding of content, develop their academic use of English, and "apprentice them into the community of math learners."

Gaarder and Hernandez-Heinz say one of their first jobs is simply to make teachers aware that second language learners need to acquire the language of mathematics in order to be successful — a new concept for many. "When high school math teachers are writing symbolically, many of them don't see all the language involved in that. They don't pay attention to the way mathematical terms have very abstract, very narrow definitions."

To help teachers learn how to model academic language and facilitate classroom discourse about mathematics, Gaarder and Hernandez-Heinz begin by giving them math articles to read and discuss together. Next, they show teachers how to create math classrooms that are rich with language-developing activities, where students are speaking, writing, and reading. Explains Hernandez-Heinz: "What we are trying to achieve is sustained quality interaction. If you don't require students to use [academic] language regularly, how can you expect them to acquire it?"

QTEL's professional development activities are grounded in sociocultural theory and research but are heavy on practicality. QTEL provides a multitude of classroom activities, examples, and tools to help teachers achieve the high-quality, sustained interaction with students that Hernandez-Heinz is talking about.

In QTEL professional development sessions, teachers engage in mathematical activities similar to what their

students might do. This experience gives teachers the opportunity to reflect on the mathematical language used and thus gain an awareness of the linguistic demands of their discipline. "Teachers who know mathematics well have been socialized into the use of mathematical language so effectively that they now use it unconsciously, without clear awareness of its characteristics," says Walqui, QTEL's director. "They need a conscious awareness of the content and the language to be taught — which are inseparable — to be able to teach with deliberateness."

QTEL professional developers also focus on key mathematical concepts — functions, for example — and their interrelationships, providing teachers with scaffolding tasks to support students' acquisition of the concepts and the related language. Tasks are designed to give students multiple entry points to understanding the concepts. Teachers might begin, for example, by accessing students' prior knowledge of the term "function": asking what students think of when they hear it and what meanings it has in conversational English. Teachers would then shift to discussing mathematical functions and would provide several scaffolding tasks to help students understand the term's more specific, mathematical meaning. Tasks might include having students sort and label cards that display functions and non-functions, then work in groups to write their own definitions of the mathematical concept.

A key aspect of QTEL's strategy is the deliberate construction of heterogeneous groups — including students at varying levels of English acquisition — that engage in well-supported activities. The goal, says Hernandez-Heinz, is to get all students to participate and to steadily increase their competency. "We are working to move students from being able to talk to their partners, to groups of four, to participating fully in classroom discussions. Every child participates at the level she or he can, as they all progress from what we call 'apprenticeship' to 'appropriation.'"

Gaarder and Hernandez-Heinz note that while talking about mathematics is important, it's not uncommon for teachers to simplify terminology instead of helping students acquire and use academic language properly. Teachers need to establish high standards for classroom discourse and expect that students can and will use appropriate, academic language. "Sometimes we make up cute terms for things in mathematics, like talking about the 'top' or 'bottom' of a fraction," Gaarder says. "Why not say 'numerator' and 'denominator'?"

Amplifying, not simplifying

English learners, the QTEL team argues, are never well-served when teachers simplify to make academic content and language more accessible. A recent participant in QTEL professional development underscored this point when she told Gaarder, "I'm really glad you're doing this because the teachers at my school are very kind and give good grades, but the kids aren't really learning."

"English learners bring a lot to the table," says Gaarder, and, given the right tools, are absolutely capable of having a rich learning experience in mathematics. She and her QTEL colleagues are certain this approach is what's needed if secondary-level English learners are to succeed in mathematics.

"We believe in *amplifying*, not simplifying," says Gaarder. Wasting time is not an option.

For more information about the mathematics work of WestEd's Quality Teaching for English Learners project, visit WestEd.org/qtel online, or contact Donna Gaarder at 415.615.3155 or dgaarde@WestEd.org, or Theresa Hernandez-Heinz at theinz@WestEd.org.

AMPLIFY, NOT SIMPLIFY, NOT SIMPLIFY

OPENING THE GATEWAY

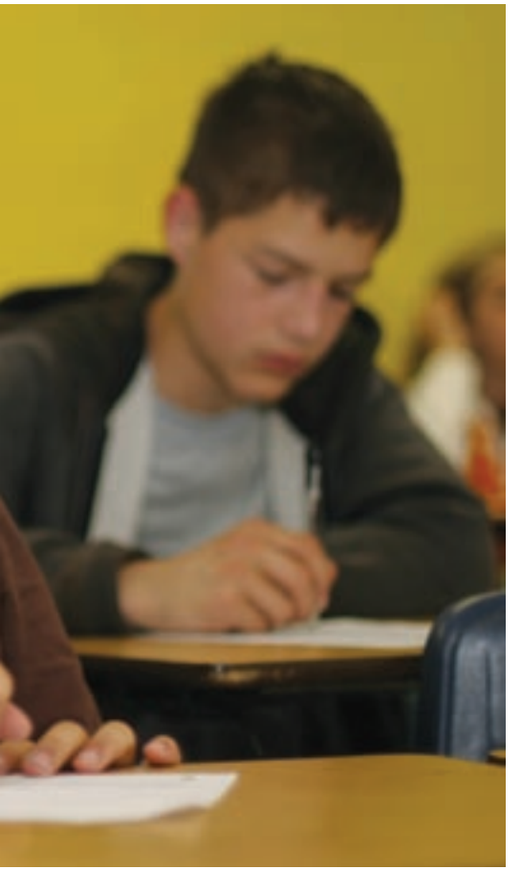
INTERVENTIONS AIM FOR ALGEBRA SUCCESS

*>>> Middle and high school students struggling to **master algebra** require instruction that addresses reasons for their lack of success. Targeted instruction needs to fill the gaps in their mathematical knowledge and emphasize **deep understanding** of key algebraic concepts.*

Providing such targeted instruction is the goal behind Aim for Algebra™, an intervention curriculum created by WestEd to boost achievement in algebra for all students, particularly those for whom algebra has been especially challenging.

"Typically, students who struggle are put in one algebra class after another and repeat the same lessons over and over," says Steve Schneider, Director of WestEd's Mathematics, Science, and Technology Program. "We've taken a step back and asked, 'What do these kids need to be successful?'"

That's an important question, given that algebra is widely considered the "gatekeeper" course that determines whether students will have access to higher education. More and more states and school districts are mandating algebra as a condition for high school graduation.



"As we look at data from urban school districts especially, we find a fairly high proportion of kids not passing algebra, which means that in a large number of cases, they won't graduate from high school," says Schneider. "Our intent is to change that by developing a curriculum to replace the materials currently being used that aren't working."

He says the Aim for Algebra program is "not business as usual" but builds on research-based learning theory. "Its purposeful sequencing and scaffolding of tasks allow students to bridge the conceptual gaps created by traditional algebra curricula."

The first six modules in the Aim for Algebra curriculum (formerly known as Algebraic Interventions for Measured Achievement) were developed with funds from the U.S. Department of Education's Institute of Education Sciences (IES). The materials were field-tested during the 2005—06 school year throughout California, where they were used with more than 1,000 students in grades 7 through 10.

The field tests found that students exposed to the Aim for Algebra modules exhibited statistically significant increases in performance on module-specific assessments. Researchers determined that each module led to increased student achievement, that the increases were substantial, and that the data showed no ceiling effect, meaning that continued student improvement could be expected.

In addition, teachers involved in the field testing rated the Aim for Algebra materials better at engaging students and helping them understand algebraic concepts than curriculum materials they had used in the past.

A second IES grant, awarded on the basis of those positive findings, is supporting the development of five more modules, a move that expands the scope of the materials to that of a full-year curriculum. Meanwhile, researchers continue to evaluate data from a randomized, controlled trial study of Aim for Algebra's effectiveness that was conducted during the 2006—07 school year.

WestEd Senior Program Manager Kimberly Viviani, who coordinates production of the Aim for Algebra curriculum materials, says the content is based on cognitive research on how students learn. As a result, activities are designed to help students understand underlying algebraic concepts in a deep way, organize their thinking, work with multiple representations, and learn incrementally.

Aim for Algebra also incorporates the wisdom of experienced math teachers and mathematicians. "We talked with a group of them about where most students encountered difficulty with algebra, and we then developed

PAGE 21

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TIVE SCIENCE INSTRUCTION

>>> For many teachers, beginning *their lessons with assessments and using student responses to calibrate instruction represents a paradigm shift. Undertaking this shift can be extremely rewarding for teachers — even for very experienced science teachers — and can boost their students' learning, says Kathy DiRanna, K—12 Alliance Director at WestEd and professional development co-director of the Center for the Assessment and Evaluation of Student Learning (CAESL).*

"Typically the test is the last thing most teachers consider. It's just something done at the end of the unit. Testing is traditionally summative, and it determines the grade. But teachers and students benefit significantly when instruction and assessment are seamless, when teachers are monitoring what they're teaching based on what they're learning from responses to the assessment," says DiRanna.

The five-year, National Science Foundation-funded CAESL project brought together educators and researchers focused on developing new strategies and tools to help K—12 science teachers strengthen their assessment knowledge and practices. The collaboration comprised professional developers from WestEd's K—12 Alliance and Berkeley's Lawrence Hall of Science; researchers from the University of California, Berkeley Graduate School of Education and from the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) at the University of California, Los Angeles; and teachers and administrators from five California districts.

As part of this effort, 40 science educators (encompassing K—12 expertise) recently participated in a three-year Science Assessment Leadership Academy to strengthen their understanding and use of formative assessment practices. DiRanna and CAESL colleagues compiled what they've learned from this work in a forthcoming book, *Assessment-Centered Teaching: A Reflective Practice* (to be published by Corwin Press, February 2008).

In the CAESL-developed approach, assessment is central to teaching — it directs planning, guides instruction "in the moment," and is the basis for reflection on

PAGE 14

> As teachers use assessment results to inform instruction and to refine their assessments for the next time, **virtually all** assessment becomes **formative.**

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student learning. As teachers use assessment results to inform instruction and to refine their assessments for the next time, virtually *all* assessment becomes formative, even traditional end-of-unit tests.

A framework for assessment-centered teaching

Given the focus on preparing students for large-scale, standardized testing in the era of No Child Left Behind, it would be easy to assume that *most* teaching has become "assessment-centered." But CAESL's focus is very different.

In fact, DiRanna says the widespread pressures of standardized testing constitute one of the main challenges to implementing assessment-centered teaching strategies. Large-scale, standardized assessments tend to have different learning goals and different criteria for quality from classroom-based, formative assessments that teachers use to adjust their daily instruction. The standardized tests tend to limit curricula to assure high scores on those tests, leaving little time for carrying out or making real use of formative assessments that can help teachers hone daily instruction.

A related challenge to implementing formative assessment is the fact that many teachers simply are not experts in assessment. While teachers take pride in their content and pedagogical expertise, many lack the knowledge or tools to provide high-quality assessment for their students.

To help teachers become more expert in creating customized, classroom-based assessments and using them to guide instruction, the Science Assessment Leadership Academy introduced participants to an "Assessment-Centered Teaching Framework" (see graphic on page 15). It captures the components of a quality classroom assessment system and helps teachers integrate assessment into their instruction.

The framework includes an "assessment knowledge triangle," representing elements of assessment that teachers need to understand — quality learning goals, quality tools, and quality use — with the vertices connected by lines representing alignment among these elements. At the center of the framework, an "assessment-instruction cycle" represents the circular relation between instruction, assessment, and re-engaging students in instruction based on evidence from assessment.

The Science Assessment Leadership Academy and the *Assessment-Centered Teaching* book provide tools and strategies to put these ideas into practice. One tool, for example, is the "Record of Assessment in Instructional

Material" (RAIM), which helps structure the teachers' planning process. Rather than relegating assessment to an afterthought, teachers make an assessment plan *before* instruction. RAIM builds on a conceptual flow in which teachers have identified appropriate learning goals and the best sequence of instruction to help students progress toward understanding these goals. The RAIM process has teachers identify appropriate assessment points in this conceptual flow — identifying where and when to step back and figure out patterns of understanding — and then select which assessments best gauge what students are mastering and what areas need more or different instruction.

A powerful new perspective

For many of the teachers involved in the Academy, following the Assessment-Centered Teaching Framework proved significant personally and for their students. Becky Reid, a 30-year veteran teacher, found the focus on formative assessment to be revelatory. The experience challenged her practice more than any professional development she'd done previously, says Reid, who has earned numerous awards for her teaching at San Diego's Sunset View Elementary School.

"I was always considered a highly effective teacher. I had done months of intensive self-evaluation and peer evaluation for National Board [for Professional Teaching Standards] certification. But CAESL quickly gave me a powerful way of looking at student responses, and that meant in some cases I had to question myself, 'Do I even need to ask this item?'"

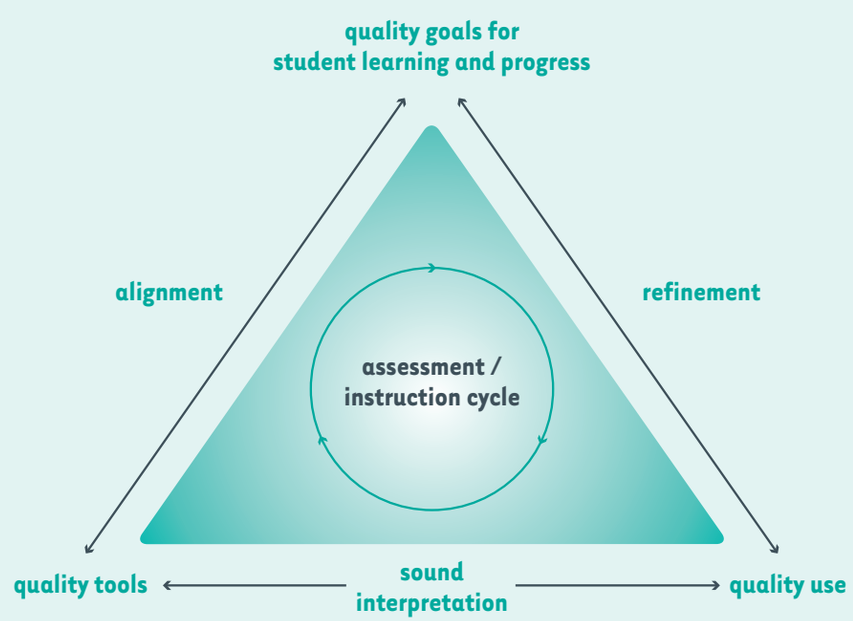
For starters, Reid learned to streamline and target her instruction. When teaching students about energy and matter, she saved about three days of instruction she'd spent in previous years providing classroom experiences with solids, liquids, and matter. Instead, she began with a simple assessment of what students already knew — called a pre-write — and found that many students retained what they had learned on those topics from previous years.

Reid also focused on streamlining her assessments. She found herself rewriting virtually every test she had given. She revised, rephrased, and eventually threw out more than half of the old questions based on closely analyzing her assessments and students' responses.

Reid also scrutinizes the publisher-provided pre- and post-tests for the units she teaches. "While those are good at letting you know if a student can select the one correct answer from a list, they don't tell you anything about a student's level of understanding."

PAGE 16

Assessment-Centered Teaching Framework



Adapted from: DiRanna, K., Osmundson, E., Topps, J., Barakos, L., Gearhart, M., Cerwin, K., Carnahan, D., & Strang, C. (forthcoming). *Assessment-Centered Teaching: A Reflective Practice.* Thousand Oaks, CA: Corwin Press.

> Most teachers who focus on formative assessment find it so **powerful for understanding** what their students know that they can't go back to thinking of testing as something that's done only for a grade.

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For example, Reid revised an assessment item that initially gave students four multiple-choice options to answer the question: "Which of the following is NOT a characteristic scientists use to classify minerals?" Her revised item describes a girl's observations of a stone she found, then asks students to identify whether it is a rock or a mineral, has them justify their answer with supporting evidence from the observations, and asks them to explain the relationship between rocks and minerals in general.

"This new prompt gives me a lot more information about what my students already know and what they need to learn to move to the next level," Reid says. "The responses inform my instruction and help me give every student an opportunity to move forward."

She provides each student with feedback on their responses, using a rubric that indicates where answers hit the mark and where they miss. Reid says her students tend to care more about their learning than when they just get a test with a grade scrawled across the top. "Now when they get a test back, they don't just shove it in their desks. With the rubrics, they're involved in evaluating their own work and actively reflecting on what they know."

Many Academy participants found the work intense but stimulating. According to DiRanna, "Most teachers who focus on formative assessment find it so powerful for understanding what their students know that they can't go back to thinking of testing as something that's done only for a grade. These teachers transform both their instruction and their assessment practice."

"We approached teachers knowing that their goals of improving their practice rarely addressed improving assessment," DiRanna adds. "But we found that through effective professional development strategies, teachers could make meaningful gains in their assessment knowledge and skills — that the novice could become an expert, and that student work could improve dramatically as a result."

For further information about formative assessment and the forthcoming book, **Assessment-Centered Teaching: A Reflective Practice**, *contact Kathy DiRanna at 714.438.3806 or kdirann@WestEd.org.*

continued from page 5

mathematical concepts. Teaching guides, for example, provide mathematically rigorous examples and explicit discussion probes so teachers learn how to guide students toward increasingly sophisticated levels of mathematical understanding.

Proven impact

MPP has been funded by grants from the U.S. Department of Education, the National Science Foundation (NSF), and the Stuart Foundation. As part of the NSF grant, WestEd researchers conducted a randomized experimental study of MPP involving 100 classrooms. MPP was shown to have a "significant impact on the mathematics achievement of a diverse population of students," reports Barnett-Clarke. And, according to the Coalition for Evidence-Based Policy, MPP has "produced meaningful effects on educational outcomes."

Barnett-Clarke says some of the most gratifying preliminary findings to come out of recent MPP classroom observation studies suggest that both teachers and students may be using MPP instructional techniques during *non*-MPP lessons.

"The preliminary feedback we're getting convinces us that teachers are adapting a lot of these instructional techniques to other lessons," she says. "They tell us it's not just the way they teach math that's changing, but rather the way they teach overall."

And as for the students, Barnett-Clarke reports that it's not unusual, even during non-MPP lessons, to hear them say things like, "That's a pitfall," and then go on to explain *why* it is a pitfall.

"What occurs through an MPP lesson just naturally influences teaching and learning," says Barnett-Clarke. "There's no need to make lots of adaptations." She describes the approach as "transformative to the students and their teachers."

MPP posters, which come with a teaching guide, are available from WestEd. Barnett-Clarke expects the entire program, which also includes videos for teachers and students, to be published early in 2008.

For more information about WestEd's Math Pathways and Pitfalls, visit WestEd.org/MPP online, or contact Carne Barnett-Clarke at 503.249.7297 or cbarnet@WestEd.org, or Alma Ramirez at 510.302.4249 or aramire@WestEd.org.

It All Adds Up

Strengthening Mathematics Teacher Leaders

>>> To bolster students' success, circles of support need to extend far ***beyond the classroom****. Teachers, for one, need* ***ongoing support*** *from professional development. But even with today's widespread emphasis on* ***improving teacher quality****, those who lead professional development for teachers rarely have opportunities to sustain their* ***own professional growth*** *to be effective in their roles.*

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Learning to Lead Mathematics Professional Development (LLMPD), a new WestEd product six years in the making, aims to change that. LLMPD provides tools and guidance that hone the mathematics understanding and facilitation skills of professional development leaders and other teacher-educators in order to improve math education.

With an ultimate goal of **improving student learning** in a large number of classrooms, LLMPD targets **professional development leaders** who in turn work with many different teachers and teacher leaders.

Up Means Better Teaching and Learning

With funding from the National Science Foundation, WestEd's Judy Mumme and Cathy Carroll videotaped hundreds of hours of math-specific professional development sessions across the country and selected clear examples that represent the issues and challenges that arise in these sessions. They then built a leadership development program in which participants use these video-based cases to identify issues and carry out constructive conversations about strategies that might work or not work in mathematics professional development.

"Leaders seldom have an opportunity to stand back and think about professional development practice," Mumme says. "Videos provide wonderful opportunities for doing so. People can play and replay a video, stop action to consider issues, read transcripts, and reflect on ideas in a way that is not possible in real time."

Supporting leaders with teaching and learning at the core

LLMPD provides a resource for people who are responsible for preparing and supporting professional development leaders. "Our materials help leaders develop their skills as professional development facilitators," says Carroll, a veteran middle school math teacher who, along with Mumme, co-authored LLMPD.

According to Mumme and Carroll, teacher leaders need opportunities to deepen their understanding of mathematics and to develop and strengthen their own vision of professional development. Teachers often are encouraged to become "teacher leaders" because of their *classroom* skills. But effective classroom skills don't always translate into knowing how to lead adult learning and don't necessarily mean the teacher has enough confidence or competence in mathematics to facilitate subject-specific professional development for others.

With an ultimate goal of improving student learning in a large number of classrooms, LLMPD targets professional development leaders who in turn work with many different teachers and teacher leaders. Mumme and Carroll draw the connections between these levels of work by recognizing that professional development has its roots in teaching and that for teacher leaders to be effective, they must understand the complexities of teaching.

Teaching involves relationships between teacher and student, student and content, and teacher and content (the inner circle of the graphic on page 20). The teacher needs to know the content of a specific lesson and must understand where that content fits into the larger curriculum and what

PAGE 20

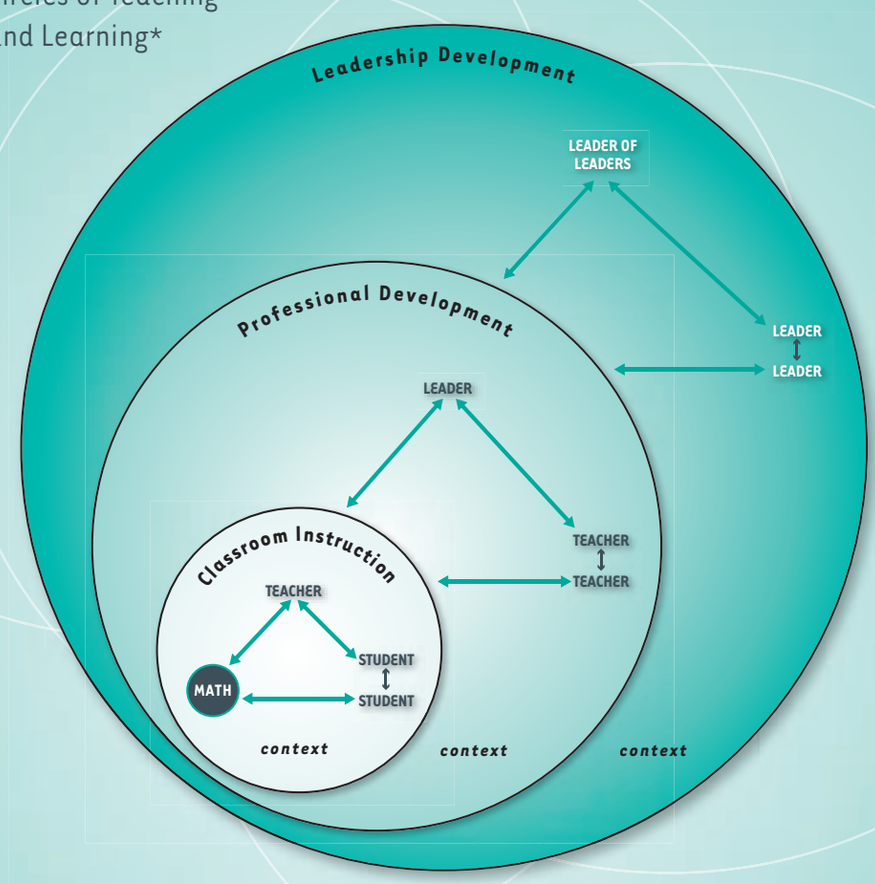
continued from previous page

is important for students to gain from the curriculum. The teacher also needs to know about her particular students and about how students in general think and learn.

Professional development adds another level of dynamics (the middle circle of the graphic below) in which the work of teaching becomes the "content," and the classroom teacher is now the learner, with the professional development leader taking on the role of teacher. In this role, the leader needs to understand the complexities of classroom teaching (the inner circle) and needs to know about the learners (i.e., the teacher participants). Knowing the learners in this case includes knowing how adults learn and how to help them with the content of teaching.

LLMPD targets an even wider circle (the outermost circle of the graphic), encompassing all of the complexity of the inner circles. When viewing and discussing cases of professional development in action, participants strengthen their understanding of and skills in leading professional development that has mathematics and improved student learning at its core.

Circles of Teaching and Learning*



* Adapted from: Carroll, C., & Mumme, J. (2007). *Learning to Lead Mathematics Professional Development*. Thousand Oaks, CA: Corwin Press.

Video case-based professional development

An introductory module of eight three-hour seminars highlights a variety of issues math teacher leaders might face and introduces a set of principles for thinking about professional development. Six subsequent focus modules — each with six three-hour seminars — build on the introduction to consider specific fields of concern, so professional development leaders can choose topics that meet their particular needs.

The focus modules tackle issues such as managing discussions; using classroom artifacts, such as student work; using teachers' explanations of mathematical tasks; choosing, using, and adapting tasks; and attending to access and equity issues.

Each three-hour session includes a video case to be reviewed and discussed at length by a group. The cases are not exemplars for participants to follow; rather, they spotlight problems for participants to contemplate and learn from. A case might deal with a teacher's confusion, for instance, or a mathematical error in an example being used in a professional development session. Carroll says, "Participants talk about ideas that come up with that case and strategies for dealing with the challenge, then we generalize beyond the video about how those strategies might help in their own professional development sessions."

The LLMPD materials guide participants through viewing each case study first with an eye toward what is going on mathematically in the scenario, then reviewing it with a focus on the leadership challenge at the scene's core.

Lessons learned

Professional development leaders have used LLMPD in a variety of ways, but Mumme and Carroll say the materials are most effective when a group commits to meeting regularly over a period of time, frequently enough for there to be a sense of continuity, but also leaving enough time between meetings to practice what they've discussed.

An evaluation of LLMPD identified several points that participants in the activities have taken away:

1. An appreciation for the importance of having a clear purpose for whatever activity they are doing in professional development.
2. Recognition that every decision has tradeoffs. If a facilitator chooses to pursue a particular teacher's question, for example, that buys an opportunity but also limits other opportunities. Participants learn to see professional development as complex.
3. Understanding the importance of having principles to guide their work. LLMPD offers a set of professional development principles to guide consistent decision-making but also encourages participants to develop principles that suit their own circumstances and style.
4. The value of knowing the mathematics. Leaders encounter trouble when they embark on a math task that they haven't thought through.
5. New instructional techniques and ways of handling a variety of professional development situations.

Originally conceived as a tool for new professional development leaders, LLMPD has demonstrated its appeal to the more experienced as well. "Groups seem to work best when they have a mix of experience in them," Carroll says. "While veterans bring the wealth of their experiences to the group, novices bring a new kind of wondering that really contributes to conversations and learning."

For more information about services related to Learning to Lead Mathematics Professional Development, *visit WestEd.org/PLMPD online, or contact Judy Mumme at 406.842.7617 or jmumme@WestEd.org, or contact Cathy Carroll at 650.381.6422 or ccarrol@WestEd.org.*

continued from page 11

modules based on what they had to say," says Schneider. "The consensus was amazing. Everyone agreed on which topics gave students the most trouble." As a result, the six modules developed to date cover: signed number operations, variables and expressions, ratio and proportion, patterns, the coordinate plane, and inequalities.

A typical Aim for Algebra lesson begins with the teacher introducing a new concept by connecting it to previous work and building on students' prior knowledge. After engaging in tasks that introduce and expand the focus of the lesson, students complete a series of activities that might ask them to represent a situation mathematically or use manipulatives to model a concept. Teachers guide students through the tasks, first with very structured instruction, then leading students to perform the tasks independently.

Schneider says these conceptual tasks are far more valuable than lessons that simply teach students to use algorithms, or procedures. "The students memorize the algorithms, but they don't understand why they work," he says. "And without that knowledge, their ability to transfer their skills to new situations is very limited."

By contrast, the opportunities for multiple representations and alternative solutions in Aim for Algebra lessons mean that students "engage topics in a deep, conceptual way that ultimately helps them be successful in algebra," says Viviani.

Woven throughout the modules is an emphasis on algebraic reasoning and problem solving. In other words, students are encouraged to move beyond

PAGE 24

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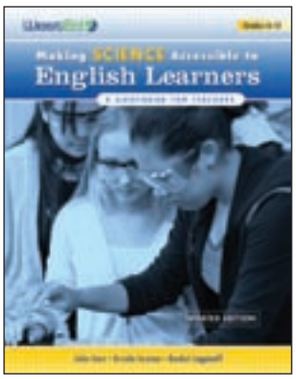

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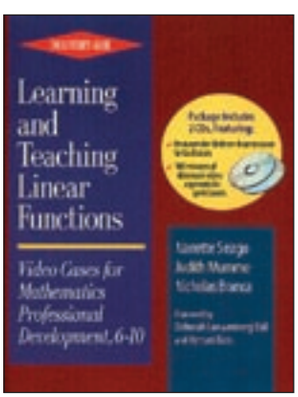

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Based on videos of real classroom teaching, focused on mathematics in grades 6-10, these materials better equip teachers to prepare and implement lessons that will help students develop conceptual understanding of linear functions. Teachers' own understanding of the subject will be deepened as they teach. The Facilitator's Package includes a Facilitator's Guide, a CD of facilitation resources, and a participant's CD with video clips and resources.

Teachers as Learners: A Multimedia Kit for Professional Development in Science and Mathematics

This innovative multimedia kit offers visual, first-hand examples of a variety of professional development strategies, including case discussions, study groups, coaching, immersion in content learning, and curriculum implementation, all targeted to science and mathematics teachers. These strategies emphasize teachers as learners and how that can be translated into student learning. *Teachers as Learners* contains everything you need to prepare staff developers to design professional development activities.

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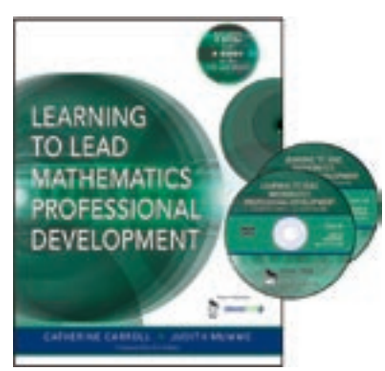
Learning to Lead Mathematics Professional Development

Designed for mathematics professional development leaders, this set of case-based leadership materials helps build facilitation skills, content knowledge, and pedagogy to design and implement effective staff development programs. Ideal for those charged with supporting teacher leaders and others who lead mathematics professional development, the kit includes a user's guide and 2 DVDs with 44 seminars containing notes, video clips, participant work, PowerPoint slides, and much more.



Authors: Catherine Carroll & Judy Mumme

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Discussion Builders Posters Set: K-1, 2-3, and 4-8

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Authors: Carne Barnett-Clarke & Alma Ramirez

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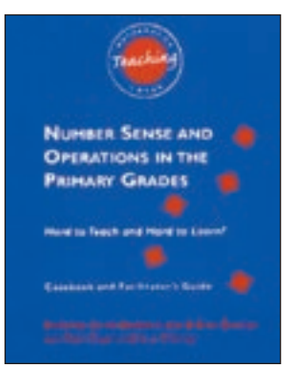
Number Sense and Operations in the Primary Grades: Hard to Teach and Hard to Learn?

This casebook enhances educators' understanding of mathematics and illustrates successful approaches to the most difficult topics related to math — ultimately leading to more effective instruction. Included are solutions to hard-to-teach topics such as place value, number sentences, basic facts, addition, subtraction, and regrouping. Following each lesson or "case" are facilitator's notes, which include synopses, sample discussion issues, suggested materials, a starter problem, and an analysis of the most vital and provocative points in the case.



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continued from page 21

"numerical thinking," which focuses on numbers and numerical answers, to considering mathematical relationships.

Viviani says Aim for Algebra was designed to be flexible. Depending on students' needs, teachers can reinforce concepts that students already have learned; refresh knowledge students may have learned, but since forgotten; or re-teach concepts that students misunderstood or never learned.

Aim for Algebra modules, which include all manipulatives necessary for implementation, can replace or supplement the math curriculum already in use. Each module has multiple lessons, and each lesson is accompanied by a teaching guide. The modules can be used in a regular classroom or in an intervention program to support students struggling with algebra. They can be used with an entire class or in small group situations. Each module also has a pretest and posttest, helping teachers differentiate and individualize instruction.

> Algebra is widely considered the **"gatekeeper"** course that determines whether students will have access to higher education.

Teachers learn to use Aim for Algebra at a two-day professional development seminar, followed by a one-day follow-up session later in the year.

Aim for Algebra is most unique, Viviani says, in the way it sequences and scaffolds specific lessons. "Each module flows from beginning to end, building on itself," she says. She is especially gratified by the enthusiasm teachers are showing for the program. "They say it's very valuable, and different from the materials available in the past," Viviani says.

So different, in fact, that in at least one class, when the bell rang at the end of the period, students did not get up to leave.

For more information on Aim for Algebra, contact Steve Schneider at 650.381.6410 or sschnei@WestEd.org, or Kimberly Viviani at 650.381.6429 or kvivian@WestEd.org.

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