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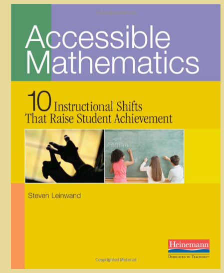

File: Mathematics

Accessible Mathematics: 10 Instructional Shifts That Raise Student Achievement

By Steven Leinwand (Heinemann, 2009)

Introduction – Why Mathematics Instruction Needs to Change

A teacher tells students that a shepherd was guarding his 18 sheep when along came 4 wolves. He asks, "How old was the shepherd?" First graders reply, "Who knows?" or "That's silly!" Unfortunately, sixth grade students give him the answer, "22." The sad reality is that our current mathematics instruction has led to mathematical illiteracy, mediocre test scores, math anxiety, and a great deal of wasteful remediation. We are falling far short of the goal that *all* students should know, like, and be able to apply mathematics. However, of all the programs, initiatives, and proposals that have been thrown at the problem, there is really one clear solution that will make a difference: *improve mathematics instruction*. Nothing impacts student achievement as much as the *quality of instruction.*

We are living in a different time in which the pressures of greater accountability mean that we need to take the body of mathematical knowledge and skills and present it in such a way that *all students* are successful. It will not work to take our traditional approaches and simply say it louder, pound it in more, or move through the topics more quickly. We need an approach to mathematics instruction that is distinct from how we were taught. The traditional American approach to mathematics only works for about *half* of our students.

From the shepherd example above, it is clear that students are not being taught to think, make sense, and reason. Instead, our monolithic approach is on lecturing and then student practice. With this passive approach, our students do *not* retain what they learn, master higher-order thinking, or learn to problem-solve. The good news is that we do not need expensive interventions to improve the situation. All we need are some basic shifts in how we teach mathematics in order to provide high-quality mathematics instruction. Below are the ten shifts that can make a real difference:

1. Incorporate cumulative review every day
2. Move beyond one right answer to incorporate higher-order thinking
3. Have students draw, describe, model, and visualize mathematics
4. Incorporate math vocabulary through language-rich discussions
5. Build number sense
6. Explore graphs, charts, and tables in depth
7. Increase the use of measurement
8. Minimize math topics that are no longer important
9. Provide realistic problems and real-world contexts
10. Make "Why?" "How do you know?" "Can you explain?" classroom mantras

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1st Instructional Shift: Incorporate cumulative review every day

All teachers know that almost no student masters new material after learning it once or twice. One student forgets the product of 9 and 7. Another can't remember how many ounces are in a pint. Because of this, one of the most important strategies to help students retain and master mathematics concepts and skills is *daily cumulative review.* Many teachers already use some kind of warm-up or mini-math to review math, but it is important to make sure that the review is: cumulative, daily, time-saving, addresses a variety of math topics, and involves good follow-up discussion.

To save time, students should be taught specific routines to get started immediately. You announce, sometimes before the bell, "Number from one to six" and students know you don't waste time. They immediately take out paper for a six-item oral quiz based on the routine you've taught them. Below are some questions you might ask. Note that the questions include a variety of mathematical areas (from estimation to drawing a picture – see the parentheses) that work in different grades even though the topics will vary.

Oct. 14 Oral Mini-Math Quiz

1. 6 x 7 (Number fact)
2. What number is 1000 less than 18,294? (Place value)
3. About how much is 29 cents and 32 cents? (Estimation)
4. What is 1/10 of 450? (Math skill)
5. Draw a picture of $1\frac{2}{3}$ (Draw a picture)
6. Estimate my weight in kilograms (Estimation and Measurement)

These daily mini-quizzes (which can also be just a few word problems flashed on the board or a screen), give you data about your students' understanding (formative assessment) AND provides an opportunity for re-teaching when you do a quick review of the answers. Have students switch papers, and then make sure you engage them in important follow-up questions rather than just checking for correctness (more on this in the next chapter). There is an enlightening description of how a teacher might go over these questions in a way that gets students to think and enhances their understanding on pp. 8-13. Below is an example of one of those discussions.

Discussion of Question 3: About how much is 29 and 32?

A discussion might go like this: "OK, number 3. Look at the paper in front of you which hopefully isn't yours. Raise your hand if your answer is 62. Wonderful. Full credit. Raise your hand if your answer is 61. Look at all the 61s in the class – that's great, also full credit. How many of you have 60? Does anyone have anything other than 60, 61, or 62? Amazing. What do you have? 37? I don't think so, unless you can justify it. (Pause to await a justification, but this is unlikely.) How do you justify 62? (One student states that she rounded 29 to 30 and then added 32.) What about 61? (One student says that it was easy enough to get the actual answer by adding 20 and 30 to get 50 and then 9 and 2 to get a total of 61.) And 60? (Another student says she rounded each number to 30.)

Discussions like this one, after the daily mini-math, reinforce a commitment to estimation (to be discussed later in the book), communicate that there are a number of different approaches, and support the development of number sense rather than a narrow focus just on getting the right answer. See the discussions of the other five quiz questions on pp. 8-13.

Overall, the follow-up discussions help reinforce a commitment to certain math values (that it is helpful to draw/visualize, that it is important to estimate, etc.), focuses the discussion on math *concepts* (not procedures) by obsessively focusing on justifications, gives students a sense of their own progress daily, and helps students review topics that might have been taught weeks or months earlier. There are also additional benefits if this daily 5 to 8 minute activity is carefully aligned to the curriculum and state test. (Note that the chapter has other examples of mini-math quizzes for 2nd grade and Algebra I as well.)

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Instructional Shift 2: Move beyond one right answer to incorporate higher-order thinking

Consider the following questions that might be asked in a reading class that is not even particularly exemplary. Students are given the sentence “Jane went to the store” and are asked:

- “Can you read the sentence aloud?”
- “Can you tell me where Jane went?”
- “Can you tell me who went to the store?”
- “Can you tell me why Jane might have gone to the store?”
- “Do you think it made sense for Jane to go to the store?”

Note that these questions progress from the literal to the inferential to the evaluative. Reading teachers do *not* stop after getting correct answers to the first three. The last questions show students that there is not just one single correct answer. Furthermore, reading teachers ask the latter questions of *all* students, not just in gifted classes. This is supported by brain research which shows that asking higher-order questions like these strengthens neural connections. In other words, higher-order questions make students smarter!

Compare this to a typical math discussion: “Take out your homework. Emily, your homework please. Okay, number one, answer 19. Any questions? I didn’t think so. Great. Number two, 37.5. OK? …” And we wonder why students have trouble grasping math concepts when we only ask for the recitation of correct answers. We need to take what we know works in our reading programs and adapt it to math instruction. Where is our discussion of “Why?” “How did you get that?” “What do others think?” or “Is that reasonable?” These are the missing questions that lead to the development of the mathematical counterparts to making inferences and evaluations in reading. Like with reading, we need to *begin* with an answer (the literal question), then move to higher-order questions.

To alter the practice of focusing on one right answer, we need to cram less in. When we assign too many homework questions it’s impossible to have the time to incorporate higher-order thinking questions into our review. Less really is more and this cannot be accomplished by racing through a 700-page textbook. Teachers certainly do complain, time and again, that there simply isn’t time to discuss alternative approaches, develop student understanding, and extend answers. However, racing through topics and assigning thirty practice problems is *senseless* if only half of our students are succeeding. If math problems can’t be meaningfully reviewed, it simply won’t sink in for many students. If students do need more practice, consider assigning homework in which two-thirds of the problems are review so students can check these themselves.

Instructional Shift #3: Have students draw, describe, model, and visualize mathematics

When Leinwand observes a math class he has a strong urge to scream, “Draw a picture!”, “Use a number line!” or “Ask them what it looks like!” Failing to have students visualize the math they are learning is one of the most detrimental missed opportunities in math instruction. Below is an example of how a teacher underscores the importance of using pictures and visualizing:

> In your mind’s eye I want you to picture three quarters. That’s all. Three quarters. Okay? Now, please erase that picture and create a different picture of three quarters. Great! How many saw 25 cents, 25 cents, and 25 cents – that is, money or coins? Raise your hands. Good – thank goodness for money. Okay, let’s see what else. How many saw pizza pies, apple pies or window panes with 3 or 4 pieces shaded? It seems most of you have shared your representations. Now it gets interesting. How many saw four objects (like balls or octopuses) and 3 of them were striped or a different color? Ah – not too many of you. How many saw a number line with a zero here and a one here so 3/4 is sitting here closer to the one? How many saw a ruler – here’s the zero and here’s the inch and you saw the little tick mark representing 3/4 of an inch? And finally, did anyone bake last night? Who saw a measuring cup that was 3/4 full?

Without teaching students to visualize, all we provide them with are abstractions. For some students, this works. For others, to make sense the math needs to be grounded in pictures or models. In fact, we need to provide them with a *variety* of representations. Think about the following common teaching experience. A teacher introduces adding mixed numbers by encouraging them to “think money.” For most students this makes sense. Furthermore, thinking about money for adding mixed numbers has always been a successful strategy for the teacher as well. However, there are some students for whom this strategy does not work. Maria says, “What do you mean by money? I don’t get this!” While it’s difficult not to get frustrated with Maria, this isn’t the student’s problem. Maria needs a different representation that works for her. She needs the hint, “think ruler” or “think measuring cup.” Rarely do students have the opportunity to process the math, see the math, or feel the math. Students need a variety of representations to truly help them understand and retain the math.

The bar model is very important in Singapore Math to help students visualize math concepts. Starting in first grade students are able to visualize a problem like 4 + 5 by using this method:

4	5

9

This model helps students visualize how fact families, like this one, are related: 4+5=9, 5+4=9, 9-5=4. This same model helps when students have a more difficult problem like: Jennifer leaves home with $14.98 and returns with $5.43, how much did she spend?

$5.43	?

$14.98

Classes that consistently have students draw, describe, model, and visualize mathematics might include activities like the following:

- Show me how big 10 square inches is with your fingers? Now show me 10 inches square. How much larger is the second?
- Draw three different pictures of $2\frac{3}{4}$
- Show me where 3π lives on the number line. How did you think that out?
- Draw and label an isosceles right triangle. How do you know it is both right and isosceles?
- If your left index fingertip is the origin, use your right hand to trace the line $y = -3x - 5$.

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Instructional Shift #4: Incorporate math vocabulary through language-rich discussions

Students who have a strong vocabulary are immersed, from an early age, in a language-rich world of context-based vocabulary. In math, students' problems often arise *not* from a difficulty with mathematical concepts, but from serious confusion with the terms and the vocabulary. This problem is only exacerbated by the fact that the United States has increasing numbers of English language learners. For example, students confuse 'area' and 'perimeter' even though they understand the concepts. It gets even more confusing in later grades, such as this example from geometry, "The projection of a leg onto the hypotenuse of a right triangle is the mean proportion between the entire hypotenuse and the length of the projection of the leg onto the hypotenuse." What a nightmare this problem is if a student doesn't know the terms. However, even a simpler sentence like this one can be confusing to a younger student who is not a native English speaker, "Write two 2-digit numbers on your paper."

The key is to include rich discussions in your class that include mathematical vocabulary. Using open-ended questions and good follow-up questions can help with this. For example, in one class about to work on a problem using the numbers 73 and 63, the teacher puts these numbers up on the board and says, "Turn to the person next to you and share five things you see on the board." Here are some of the responses that have emerged:

- Two odd numbers
- My grandparents
- A take-away-10 pattern
- Two 2-digit numbers
- The high and low temperatures
- My last two math test grades
- Two numbers 10 apart
- A sum of 136
- Three unique digits
- One prime and one composite number
- Threes in ones place of both numbers

Good follow-up questions are what leads to a discussion that involves math terms and vocabulary. For example:

- Convince me that they are both odd numbers. ("They both end in an odd number, "Neither can be divided by 2," etc.)
- How do you know they're 10 apart? ("The difference is 10," "The units digits are the same and the tens digits are 1 apart," etc.)
- Which number is prime and which is composite? How do you know?
- If these are your last two math scores, what is the mean of these grades?

Look at the vocabulary that is woven into these discussions with terms like: odd, digit, difference, prime, composite, mean, etc. Look at the following example on a high school level. A teacher writes $f(x) = x^2 - 3x + 5$ on the board and asks students to note three things they see. Collecting their responses, she writes the following on the board:

- A function
- A constant
- An equals sign
- A quadratic
- A trinomial
- A parabola
- Coefficients
- A linear term
- Two roots
- Three terms
- A second-degree polynomial
- A U-shaped curve that opens upward

Without a familiarity of these terms – that comprise a significant portion of the vocabulary needed in a quadratic functions unit – a student would be at a distinct disadvantage. Of course the real work in this exercise is the discussion afterwards which includes questions such as:

- What makes it a trinomial?
- How many coefficients does the equation have?
- How do you know it opens upward?
- What makes it a quadratic?
- What makes it a function?

In class students need to be bombarded with key mathematical terms, like these, both orally and in writing. These terms must be used again and again, in context, and must be linked to more familiar words until they become internalized. Familiar words can be particularly helpful when you emphasize that "perimeter is border" or "circumference is the pizza crust" or "a centimeter is about a pinky fingernail."

Instructional Shift #5: Build number sense

Below is a typical test item:

Tom has \$10.00 and sandwiches cost \$1.89 each. What is the greatest number of sandwiches that Tom can buy? a. 5 b. 8 c. 11 d. 18

Our brightest students do not foolishly try to find the quotient when dividing \$10.00 by \$1.89. They simply use number sense to see that at almost \$2 each, Tom can only buy 5. Number sense is a comfort with numbers that includes facility with estimation, mental math, numerical equivalents, a sense of order and size, and a deep understanding of place value. Number sense should be one of the overarching goals of mathematics instruction. One way to keep number sense present in your class is to continually pause, regardless of the topic, and ask questions such as:

- Which is the most or greatest? How do you know?
- Which is the least or smallest? How do you know?
- What else can you tell me about those numbers?
- How else can we express that number? Is there still another way?
- About how much would that be? How did you get that?

In the typical mathematics curriculum there is too little focus on number sense. Take place value for instance. It is usually only studied in an early unit in the school year and is often confined to inane questions like, “What is the value of the 8 in 4289?” and “What digit is the hundredths place of 4.2958?” Given that place value is an important part of number sense there is a vital need to go beyond this superficiality. We need to ask more important questions and we need to ask them over and over again:

- About how much is that?
- What’s 10 or 100 or 1000 or one-tenth or one-hundredth more or less?
- What’s 10 or 100 or 1000 times as much as that number or one-tenth or one-hundredth of that number?

For example, if 25.925 is the answer to a problem your class completed, you can bring number sense into the conversation by asking:

- About how much is that and where did your approximation come from?” (Estimation)
- On the number line, is this to the left or right of 25? Is it closer to 25 or 26? Why? (How much? Rounding)
- What’s a tenth less than this number? A tenth more? How did you get that? (Place value)
- What’s a hundredth less? What’s a thousand times this number? (Place value)

In fact, every number that comes up in math class presents an opportunity to strengthen number sense. Leinwand is known to announce, “As of this morning my age is 28,935,285!” Then he asks students to guess what unit of time it is (days? hours?) based on an estimation of how many years old he is (53). From one interesting claim (his age in minutes) the ensuing conversation is filled with number sense skills such as measurement, time units and conversion, place value, and rounding large numbers.

Like with number sense, there are so many missed opportunities to explore graphs, charts, and tables in depth. For example, one textbook gives the following exercise (with an absurd context for today's students) and asks for only *one* answer:

Based on this chart, which concert has the greatest number of tickets sold?

Concert	Tickets Sold
Beethoven	385,204
Mozart	259,593
Haydn	285,447
Chopin	327,982

As Leinwand puts it, "four luscious 6-digit numbers" and the problem only asks for the largest one! As he always emphasizes, there are a number of rich questions that would truly milk the data for more than one simple answer and help students develop their number sense. Below are a few:

- About how many tickets were sold altogether?
- Which concert was probably the least popular?
- Did they reach their goal of selling 1 million tickets?
- Which concert sold closest to 300,000 tickets?
- About how many more tickets were sold to the most popular concert than to the least popular?

There are other approaches to the data above that would also reinforce number sense. Students could be given the chart and come up with their own questions to answer. Or, the teacher could put up the data (without headings) and ask what it might represent:

385,204
259,593
285,447
327,982

Working in pairs students can make inferences about these four 6-digit numbers (remember the value of introducing successful literacy practices in math class from earlier? We rarely make inferences in math!) What might the context be? (populations, size of countries, etc.) What might the unit be? (numbers of people, square miles, etc.) Then students could judge the reasonableness of their answers (Is there a country with just 385,204 people?) Many real-world applications of math involve graphs, charts, and tables as do many test items. By asking good questions to "milk" the data, we can best prepare our students to understand that data. The chapter contains several additional examples of "milking" the data. Below is one of them:

What could be the story behind this data?

Weeks	Roger	Jamie	Rhonda
0	210	154	113
2	202	150	108
4	196	146	105

There are a range of possibilities, but many students think about diets. If so, follow-up questions could include, "At this rate, what will each person probably weigh after 6 weeks?" and "Which person is doing best after 4 weeks?" and "Which dieter is the smartest?" These kinds of questions will reinforce the idea that there can be multiple solutions. Perhaps some think Roger has done the best because he lost the most weight, but consistent dieters keep the weight off better and Jaime has been most consistent. Some might say Rhonda did the best because she lost the greatest *percentage* of her weight. The point is that students are encouraged to justify their solutions and this leads to the development of important thinking and reasoning skills.

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Instructional Shift #7: Increase the use of measurement

In the mathematics curriculum, no area is as weak as measurement, and no chapter is as regularly skipped or raced through as the one on measurement. Furthermore, looking at national data on student mathematics performance (such as on the NAEP) our students' performance is embarrassingly weak in measurement. Perhaps it is skipped to spend more time on computation or because it's complicated to teach both customary *and* metric measurements. In any case, measurement continues to be one of the weakest parts of the mathematics curriculum. As with the other instructional shifts suggested, mathematics teachers need to make measurement an ongoing part of their instruction.

Let's look at typical mathematics instruction in measurement. "Good morning class. Today's objective is to find the surface area of right circular cylinders." (You may be following the protocol of stating the objective, but you've lost half of your class by doing it in this way!) "Please open your books to p.384 and look at the formula **Surface Area =** $2\pi rh + 2\pi r^2$ and let's find the area of the figure."

In addition to losing the interest of the students, the problem is missing a lot – a context (a soup can, a barrel of hazardous waste), some measurement units to add to the reality (inches, meters), an estimate of the surface area, and an explanation of *why* the formula works and where it comes from. Instead, the lesson here focuses on memorizing a formula students know nothing about.

Here's an alternative that actually gets them interested in measurement and goes deeper at the same time. "Good morning class. Remember my son Ethan? Well, when he was 16 he badly cut himself and we went to the ER. In the waiting room, sirens start blaring and two nurses rush in. One says, 'This is serious. The next patient is *completely* burned.' The other says calmly, 'Don't worry, he's an adult, so just order up 1000 square inches of skin from the skin graft bank.' So class, which response is more appropriate: 'Phew, oh good' or 'Oh dear'? Explain your reasoning."

Many students want to know how big the guy was and if he died. You know you've piqued their interest when they personalize the situation, "It could have been me" or "I care because I don't want to be burned." Furthermore, there is a great deal of important measurement and thinking in figuring out the reasonableness of ordering 1000 square inches of skin. Below are some typical responses:

- "We thought we could use a paint roller and paint the front of your body. Then when you walk into the wall, we could measure the paint splat. We estimate it is about 70 inches high and 18 inches wide, so that's more than 1000 already and we haven't painted your back. So there's no way 1000 is enough."
- "We thought that our bodies were cylinders or like the cardboard inside paper towel rolls. We figured an adult was about 70 inches tall and about 36 inches around for a total of more than 2000 square inches so 1000 couldn't be enough."

These, and the other examples of student thinking in the book, are examples of getting students to do real thinking and reasoning as they engage in concepts such as area, surface area, estimation, and others. Imagine the discussions that follow from more thought-provoking questions about measurement such as:

- How big is your desk?
- How many rolls of toilet paper would it take to surround the school?
- What's the average weight of our loaded backpacks as we leave to go home?
- Could we fit the entire student body of the school into our classroom?

Instructional Shift #8: Minimize math topics that are no longer important

Changing *how* we deliver instruction will lead to the most significant changes in math instruction. However, it also helps to address the issue of *what* we teach and *when* we teach it. Textbooks are stuffed with too many topics for teachers to cover them all well. Furthermore, it just does not make sense to continue to teach certain topics.

For example, can you remember the formula for the volume of a sphere? Unless you are a teacher who has recently taught this topic, most people can't recall the formula and they don't care – because there are many places to find it if it is needed. Not only does the formula itself have little to do with understanding volume, but *every* SAT, ACT, GRE and high-stakes state test *provides* a sheet with the formula for volume to students. Yet we insist that students memorize this formula. This is just one example of how our curricular expectations are at times out of step with the real world. So what exactly are the mathematical topics that waste our students' time and do little to support mathematical success for them? For example, while mastering basic number facts might be essential, far too much time is spent on the obsolete task of manually computing with 2- and 3-digit numbers. This is a nuanced and controversial topic, but below are some areas Leinwand suggests cutting:

- Multi-digit multiplication and division – When was the last time you used pencil and paper to find 2953 divided by 15.9?
- Sevenths and ninths – When was the last time you encountered these fractions in real life?
- Complex, rarely used formulas – When students have formula sheets do they really need to memorize the formulas for spheres, cylinders, pyramids, and cones?
- Simplifying radicals – In a world of calculators does it make sense to take time simplifying $6/(\sqrt{10} - \sqrt{7})$?
- Factoring – Of all the possible quadratic trinomials in the form $ax^2 + bx + c$ only about 3% can be factored into binomials with integral roots, yet we spend a lot of time on this.

Leinwand also contends that we are teaching more math and harder math to students in earlier and earlier grades. Students are often not yet ready and we set them up to fail. We need to understand that textbooks are often created to meet diverse curricula in different states and teachers cannot possibly "cover" a textbook of more than 800 pages. It is time to take a look at what we teach and skip some chapters so we can teach in a way that ensures students learn the material.

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Instructional Shift #9: Provide realistic problems and real-world contexts

In so many middle or high schools today it would not be uncommon to see a math assignment like this on the board:

229	224	219
1-19 odd	2-22 even	31, 34, 36

This is not an approach that solicits high levels of engagement. Instead, imagine the opening of a math class (after a 6-minute mini-math review) that looks like this – A teacher brings in a colorful copy of the *Guinness Book of World Records* and uses a computer and projector to post the following, "Peter Dowdeswell of London, England, holds the world record for pancake consumption." This provides an intriguing context that attracts student attention and interest. Below is a possible dialogue that might ensue:

Teacher: Is there anything you would like to know?
Michelle: Yes, how many pancakes he ate.
Teacher: And why is that?
Michelle: Because it's a world record and I want to know the number of pancakes he ate.
Rodney: I want to know how big they were. If he ate a lot of very small pancakes, it's not as impressive as if he ate a lot of normal or big pancakes.
Teacher: So, what information would help you with the size of the pancakes, Rodney?
Rodney: I guess I'd like to know the diameter of each pancake, assuming they are round.
Laticia: I think we'd also need to know the thickness to have a sense of the volume… etc.
Teacher: Wonderful. Here is what the book says, 'He consumed 62 pancakes each 6 inches in diameter and 3/8 inches thick in 6 minutes and 58.5 seconds.'

This leads to a great variety of math topics such as rate, multiplying fractions, volume, graphing, and more – and it is done in a way that not only provides a context, but an intriguing one (food consumption!) to the students. For younger grades this might involve a restaurant menu and price list. For example, rather than simply giving students the comfortable problem, "Find the quotient of 15 ÷ 2.29" and focusing on the *procedure* of division and how many spaces you move the decimal place over, there is a more engaging alternative. Tell everyone they have $15 and with a coupon, the price of a Burger King Whopper has been lowered to $2.29. Instead of asking what the quotient is, or limiting yourself to asking "How many can you buy?" ask a series of interesting questions:

- What's the change if you only buy one?
- How many can you buy?
- Can you get 10 Whoppers?
- What about sales tax?
- About how many can you get? (Estimation)
- How do you know?

The following discussion -- which involves reasoning, estimating, and justifying -- is a much more engaging approach and gets at a deeper level of mathematical thinking than the "Shut up and follow the rules of moving decimals" approach. There is no doubt that teaching this way is harder to do, takes more time to plan, and is messier. However, this messier approach is the one that is more likely to make the math more accessible to more students and help with the goal of mathematical power for all.

Instructional Shift #10: Make "Why?" "How do you know?" "Can you explain?" classroom mantras

Another seriously missed omission in mathematics instruction is not following up on a student's answer with "Why?" or "Can you explain your thinking." We are often programmed to stop after the correct answer is given. Math classes are often peppered with answers that are limited to one number or just a few words: "A proportion," "85," "They're congruent." But how do we know that a correct answer represents correct thinking? How do we know that those students who did *not* raise their hands now understand? Asking "why" provides insight into a student's thinking, provides an explanation that *all* students in the class get to hear, sends the message it is safe to provide different answers and take risks, and sets the expectation that students can learn from each other. Consider what you might get when you ask "Why?":

- A sound explanation that shows student understanding and can help the rest of the class
- A faulty explanation that reveals a thinness of understanding or the student's inability to articulate ideas
- An opportunity to ask other students for alternative explanations
- An opportunity for other students to take the explanation they heard and put it into their own words

Asking a student who gets the *wrong* answer to provide an explanation is also useful because often the student will recognize the error and self-correct. Then the teacher does not have to be in the position of saying, "No, you're wrong." Overall, we need to go further than the correct answer. Leinwand describes himself as obsessive about asking students "why?" Asking for an explanation sends the powerful message that good mathematical thinking just *begins* with the answer.

Putting It All Together

To implement these ten instructional shifts it takes *time* and it takes *planning.* The current approach to lesson planning will not support the approaches introduced in this book. Take a look at a typical small square in a planning book:

SOLVING PROPORTIONS
Do pg. 343 Examples 1 and 3 on the board
Guided practice p. 345 2, 4, and 10
HW p. 346/ #11-25 odd p.342/ # 8-20 even p. 335/ # 1, 34, 39

This plan does not even begin to outline why proportions are important, when you use them, what a real-world context might be, what common errors or misconceptions students might have, how students should participate, and much more. Back in the time when all students were *not* expected to master the math, this might have worked. However, now we are expected to find ways to make math work for *all* kids, and we need to plan more carefully in order to do this. Effective planning must address a number of elements the minimalist plan leaves out. The Core and More Lesson Checklist provies a template for lesson planning.

However, implementing the ten instructional shifts introduced in this book, while seemingly straightforward, actually entails a significant change for many teachers. We need district-level administrators to support principals, and principals to support teachers in this new approach. Only then will we truly get our students to engage in new and powerful mathematical behaviors. Furthermore, professional collaboration is a necessity. While we might see changes in *some* math classes, insuring school- or department-wide implementation of these instructional shifts requires professional collaboration. Teachers need to discuss the ten instructional shifts as well as what is and what is not working for their students. If we want to make sure that more students master more mathematics, we cannot continue to do what we've always done. We already have many of the answers to this challenge in the ten instructional shifts. Now we need to institutionalize these practices throughout classes so that mathematics will be taught better and students will learn more.