Math Engagement Linked to Grasp of Concepts by Angela Hooser

Are we preparing our students for a future that focuses on new innovations in math? The latest Trends in International Mathematics and Science Study (TIMSS) says not (Stigler, 1999), and I tend to agree. Looking at the curious faces of the 4th graders surrounding me, I wonder how I can best ensure that my students are equipped to not only solve the math problems presented today, but also devise solutions to the problems of tomorrow.

Author Daniel Pink (2005) offers a new way of looking at the old struggle between memorizing facts and the conceptual-based mathematics standards presented by the National Council of Teachers of Mathematics in 1989. Pink describes a past in which simply knowing how to perform a task is enough to thrive. He asserts that our future leaders should be able see the big picture and be adept at pattern analysis (Pink, 2005).

I see this as a fresh perspective on math and on education. Our students must know how to perform procedures as well as understand why those procedures work.

Rethinking Multiplication Strategies

I decided to focus on multiplication to further explore the idea that an understanding of numbers is as important as fluency in procedure. My students had been drilled on their multiplication facts. Yet, once either factor rose above the number five, the answers became elusive. Even my students who were capable of figuring out the problem did not have efficient strategies to do so. I could practically touch their frustration and feel their sense of failure. I needed another way.

After an initial assessment, I found that my students were able to use repeated addition and could construct arrays, then find the area with numbers such as 11 × 12. Although this method was promising for smaller numbers, it would be inefficient for larger numbers. But the most striking change was in attitude. I gave my students no strategies; rather, I simply asked them to show me how they could figure out the problem. The tone in the room was positive. They felt successful. I felt it was a good start.

I then focused on applying the distributive property and supporting student-generated strategies: I began each lesson with number strings focusing on using known facts to solve for unknown numbers (Fosnot & Dolk, 2001), such as 2 × 6 = ?, 10 × 6 = ?, and finally 12 × 6 = ?. Students then explained how they solved the problem using the previous or other known facts to break apart the problem.

Applying Strategies to New Problems

As my students explored their own solutions, I looked for new strategies through whole-group sharing about operations such as double (or quadruple) addition and decomposing numbers (Baek, 2006; Caliandro, 2000). It didn't take long for them to solve problems such as 14 × 9 in multiple ways. For example, if 14 + 14 = 28, and 28 + 28 = 56, then 14 × 4 must be 56, so 56 + 56 = 112 plus an additional 14 equals 126, or 9 groups of 14. Other students found it easier to decompose the problem into 10 × 9 + 4 × 9 which equals 90 + 36 or 126.

After only a week of practice, my students had achieved these goals of recognizing and using the distributive property to create their own strategies. Furthermore, most students were mentally multiplying one-digit by two-digit numbers.

Over the next few weeks, we began to use our strategies with larger numbers. I noticed as the numbers increased, they fell back on less efficient strategies—for instance, by trying to solve problems such as 24×18 by adding the number 24 repeatedly 18 times. I addressed this by turning to our place-value system and number strings focusing on multiplying multiples of 10. Strings such as $10 \times 10 =?$, $1 \times 100 = ?$, $1 \times 1000 = ?$, and $10 \times 100 = ?$ clearly illustrate a pattern.

I also used graph paper and place value cubes to bridge from an expanded form algorithm to the standard algorithm (Hyde, 2006). Each student pair began by marking off the dimensions for a 9×14 array on graph paper. We began with the 100-place-value cube and placed it on our graph. We then outlined and labeled the 100 squares. We continued with 10s and units. I then asked students how they could figure out the number of total squares without counting by one.

Both my students' abilities and their confidence continued to soar. They were now able to see the link between their work and the way their parents were doing a more traditional math. Our previous work with place value and the distributive property allowed my students to begin solving using more conceptual understanding. For example 19×20 could easily be solved by multiplying $10 \times 20 + 9 \times 20$. I found myself with a room full of students who could not only perform the procedures involved in multiplication, but also apply their own strategies to solve new problems.

Now only one decision remains: should I require my students to use the standard algorithm? I have left it up to them. In the words of one student, "I would rather do it my way—I know I'm not missing any parts," which means that she breaks the numbers apart using expanded form and then solves problems with numbers she is more comfortable with. With increased understanding of our number system, she is able, like many of my students, to develop strategies that not only work, but also—and more importantly—make sense to her. Her reasoning is good enough for me.

Building Confidence to Take on Challenges

Now I see students who feel confident in their abilities as mathematicians and find joy in sharing their work with others in our classroom community. As an educator, improving my students' ability to solve problems autonomously is my ultimate goal. After all, if our students are able to understand underlying math concepts, there is no limit to what they can and will achieve. Believing they can is only the first step.

Our nation currently faces a shortage of Americans willing and able to take on STEM challenges. But I say that with an increased understanding of mathematical concepts, our children will have the ability to take on these challenges and the confidence to surpass any expectations.

References

Baek, J. (2006, January). Children's mathematical understanding and invented strategies for multidigit multiplication. *Teaching Children Mathematics*, *12*(5), 242–247.

Caliandro, C. K. (2000). Children's inventions for multidigit multiplication and division. *Teaching Children Mathematics*, *6*(6), 420–426.

Fosnot, C. T., & Dolk, M. (2001). *Young mathematicians at work: Constructing multiplication and division*. Portsmouth: Heinemann, Inc.

Hyde, A. A. (2006). *Comprehending math: Adapting reading strategies to teach mathematics, K–6*. Portsmouth: Heineman.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: The National Council of Teachers of Mathematics, Inc.

Pink, D. (2005). *A whole new mind: Why right-brainers will rule the future*. New York: Penguin Group.

Stigler, J. A. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: The Free Press.