

Teaching mathematics is so much harder than knowing or doing math oneself. Knowing math is necessary but not at all sufficient for helping others understand it. Of course one certainly can't teach something that one doesn't know. But the work involved in making explicit what particular concepts or operations mean, and why certain procedures work, is different from solving one's own problems or justifying one's own solutions. Teaching requires more than this sort of explicit, unpacked, sense-making approach to understanding. Helping others learn demands a flexibility with ways of explaining and representing the content—when one approach doesn't seem to help, teachers need alternatives.

But teaching is also more than explaining content *to* learners. Teaching involves listening to learners talk, reading learners' mathematical writing, and trying to make sense of what learners know—and also what they don't. The mathematical agility required in making sense of someone else's mathematical thinking or work is demanding. And teachers must do this with twenty-five, thirty, or even more students at the same time. This sort of mathematical work depends on what my colleagues and I have called *specialized* mathematical knowledge, because it is so particular to the specific uses to which teachers have to put their mathematical understanding.

A big challenge for most of us who teach elementary students is that when we were their age, we were not taught in ways that unpacked the mathematical meanings or exposed the underlying ideas. Often there was more focus on memorizing rules and developing fluency. If this was what we experienced when we learned math, it means that developing our skills as teachers often involves unlearning how we learned math *and* learning it in new ways.

Beyond Invert & Multiply is a mathematics resource written expressly for the work of teaching. The sequel to *Beyond Pizzas & Pies, Second Edition* (McNamara and Shaughnessy, 2015), *Beyond Invert & Multiply* delves into the mathematics of fraction computation, an area of elementary mathematics that is often opaque to students, and over which they often stumble. For many children, fraction computation is where they begin to struggle with math. This not only affects their learning but also their confidence and interest. And facility with fractions is one of the most important foundations for middle school and beyond. Further, when students struggle, they sometimes begin to see mathematics as senseless and not learnable. The content can seem so strange compared to their earlier work with whole numbers. Now $\frac{3}{8}$ is less than $\frac{1}{2}$, even though 3 is greater than 1 and 8 is greater than 2. And adding $\frac{3}{8} + \frac{1}{2}$ is not $\frac{4}{10}$. Multiplying fractions seems easier—after all, $\frac{3}{8} \times \frac{1}{2}$ is equal to the products of the numerator and denominator, or $\frac{3}{16}$. But why the product, $\frac{3}{16}$, is less than either $\frac{3}{8}$ or $\frac{1}{2}$ is not obvious. Doesn't multiplying two numbers result in a "bigger" number? And dividing fractions is perhaps the most mystifying of all. How can $1\frac{3}{4} \div \frac{1}{2} = 3\frac{1}{2}$? But the procedure—invert and multiply—yields just that. The problem is that, while students become more and more mystified, and less and less connected to the meaning of what they are doing, we as teachers are often unprepared to help. When many of us were in fourth grade, the procedures were enough and no one regularly asked what the answers meant. Even if we ourselves had

experience making sense of fractions in school, we still often have more to learn in order to be able to help learners—who are not us—understand the content.

Beyond Invert & Multiply is a professional mathematics resource for teachers. It opens the mathematics up with diagrams, clear explanations, and classroom scenarios. Ideas and procedures that seemed opaque are made transparent and reasonable. Math that was not part of our own education suddenly makes sense. The insights that Julie McNamara's expositions offer are illuminating and exciting. But *Beyond Invert & Multiply* is more than that. It is a resource for our work, the work of teaching. Filled with examples from classroom teaching of fraction concepts and computation, the resource gives activities, tasks, and tours of what our learning can be like. Readers who study this resource and watch the video clips will learn math from the teaching described and shown. They will also learn ideas about teaching.

As the standards are raised for students, the challenges for teachers are also higher. This resource could not be more timely, more respectful of, and responsive to teaching. It offers just the right amount of support to help teachers provide skillful mathematics instruction for all their students—and it's concrete and flexibly usable. Confronted with teaching the subtraction of fractions, a teacher could delve directly into Chapter 4 without reading the previous chapters and immediately be immersed in the ideas relevant to the mathematical and instructional demands of this topic. Written for the practice of *teaching* mathematics, *Beyond Invert & Multiply* is a mathematics resource essential for the work of teachers.

By supporting teachers, *Beyond Invert & Multiply* will help young learners arrive at middle school equipped with foundations of understanding and confidence. And their learning, in the end, is the point.

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