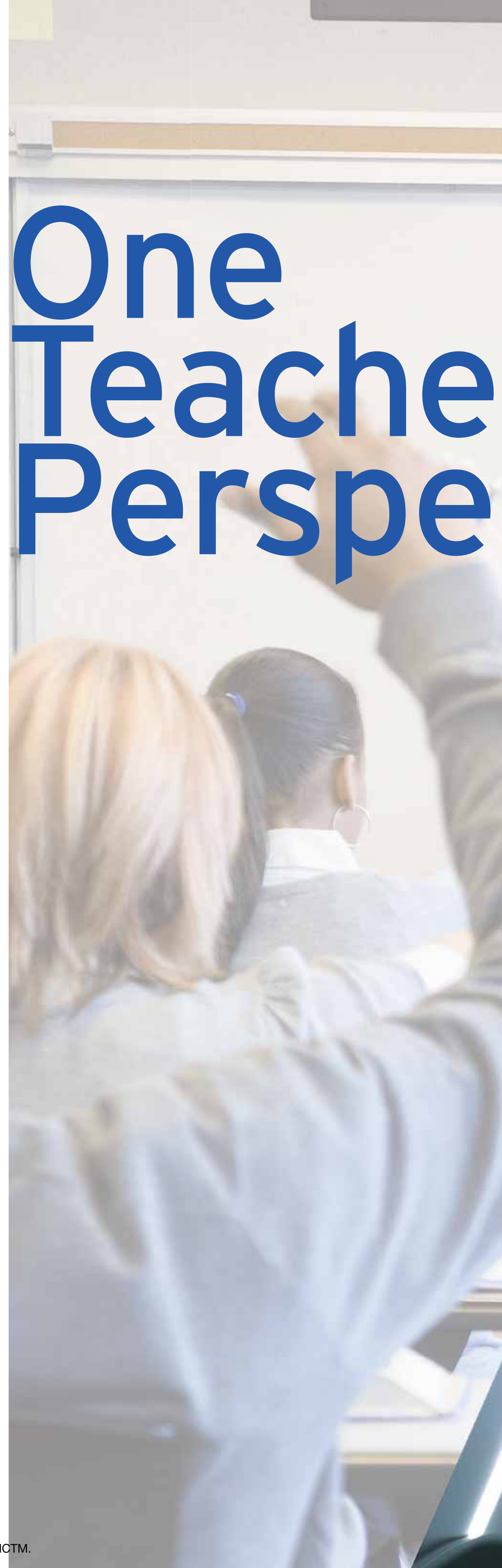
Changing Classroom Instruction: One Teache Perspe



After many years of looking for effective teaching practices, a high school teacher now sees where the focus of change needs to be.

Penelope P. Tolle

“How easy is it to change how we teach?” There was a time when I asked that question every time I heard talk about what the ideal mathematics classroom should look like—engaged students, discourse, rigor, scaffolding, and questioning of various kinds embedded throughout each lesson. With the implementation of the Common Core State Standards, many of these behaviors now appear within the Standards for Mathematical Practice, on which students can be assessed and teachers will be held accountable. If changing the way we teach is an easy thing to do—and there are those who imply that it is easy—then why aren’t all teachers equipped with the ability to attain all these desired practices in their classrooms when they first leave their university preparation programs and begin teaching?

The answer is that changing the way we teach is not easy, nor does it happen instantaneously. I am not the first to write about the difficulties of

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change, especially the time it takes to make changes (Edwards and Townsend 2012). I spent years making the changes in my teaching methods before realizing where change really needed to occur. So it is important that I first describe some of the major outward changes that I made—that many readers will probably see in their own teaching—before talking about the more effective change I made in my perspective on teaching.

EXPLAIN YOURSELF

I began changing my teaching methods in 2001, after eight years of teaching, when I was teaching developmental-level mathematics courses at the local community college. Having taught previously at an international private school, I knew just how important these early concepts would be to later courses. We were at the end of a unit on fractions, and, as I had been doing all semester, I encouraged students to share their different solution methods with the class.

In this case, the problem was subtraction of mixed fractions:

$$4\frac{3}{5}-1\frac{4}{5}$$

The last student to come to the board used a solution method that I had not anticipated. Subtracting the whole numbers gave him a 3, and subtracting the fractions gave him –1/5. But then he took the solution one step further than other classmates who had used the same method. He performed the signed number calculation, which resulted in the correct answer:

$$3+\left(\frac{-1}{5}\right)=2\frac{4}{5}.$$

At that point in my teaching career, I taught from the front of the room. I did little walking around and relied on students to let me know whether they had questions about what they were doing. Luckily, this student had not asked for help in solving this problem, because I might have encouraged him to use another more common solution method. But there was nothing wrong with his method. In his method, he had applied prior knowledge of signed numbers, which all the students in this class had already been exposed to.

I left that class knowing that I was not as prepared as I needed to be for each day's lesson and each student's possible contribution. I needed to stop teaching concepts in isolation and think more about where students had been and where they were going next. But what exactly does that change look like when I am preparing a lesson? The answer was just a guess on my part; I had no one and no model to reference. At that time, much was being written about using questions effectively, so that is what I focused on in changing in my lesson. I saw using questions as a way to hear and see more of my students' mathematical thinking.

Four years later, I was teaching algebra at a public high school. I was still teaching primarily from the front of the room, because I felt it was more effective. Answering a student's question from the front of the room allowed everyone to hear and benefit from what I considered to be a discussion. I could also call on someone else to answer a classmate's question, thus allowing a greater number of students to share their own ideas. My questions were improving, and I was using them also to guide students in connecting the different mathematical concepts and methods of solution. Typical questions were "What led you to use that method?" and "How is your thinking similar to [or different from] . . . ?"

But I stumbled every time a student offered

something incorrect to the conversation. I knew that it would be wrong to say, "No, that isn't correct." The solution suddenly came to me one day when I really wanted to know how a student had arrived at the wrong method and found myself wondering what that student was thinking at the time. After that, I began using the same cue for incorrect student contributions as for correct solutions: "Explain how you got that." I found that students, while explaining their own work, would often stumble on their own mistake and correct it; thus, they benefited from talking through their error.

CHANGES MADE

In summer 2007, I had the opportunity, as part of a lesson study immersion program, to go to Japan, whose students have done extremely well on international tests. I spent two weeks observing mathematics being taught at different levels, from the primary through the middle school grades, at schools throughout the country and witnessed both the classroom and postobservation segments of the lesson study process. While there, I also had the opportunity to observe and talk with mathematics education professors and preservice students at two universities. This trip gave me the teaching model that I had been looking for. But what I discovered on my return was that trying to put what I observed in Japan into practice in America was not an easy matter.

I continued to make changes to my own teaching, drawing on what I had observed and had been a part of in Japan but also on books and articles about lesson study by Catherine Lewis (2002) and others. Smith and Stein, in their *5 Practices for Orchestrating Productive Mathematics Discussions* (2011), provided an outline of a mathematical lesson that is extremely similar to the Japanese model. I did what I could to plan and implement lessons following a combination of all this input. I drastically reduced my time at the front of the room; added space on my seating chart so that I could circulate around the room and make notes about how students were approaching and solving problems; and tried not to assist them or direct them when they got stuck. I rewrote old problems to increase rigor, aligned problems better with objectives, and encouraged students to think on their own by choosing to hear what they had to say about their approach and then ask questions, rather than show them what to do. I organized the discussion at the end of a lesson to direct students to a deeper understanding of the mathematics. Professionally, I participated in workshops, took graduate-level courses, went to conferences, and participated in webinars. In retrospect, I notice that I had always been making my changes be all about changing me and what I was doing as a teacher.

SIX PRINCIPLES OF QUALITY MATHEMATICS INSTRUCTION

Then, as I was preparing to join the Common Core adventure, I read the article "Intellectual Engagement and Other Principles of Mathematics Instruction" (Peterson et al. 2013). After studying pre- and postlesson discussions between Japanese preservice teachers and their professors, the authors detailed six principles that seemed to them to characterize Japanese teachers' conception of high-quality mathematics instruction. The article helped me understand that what I really needed to do, and what I had seen done so successfully in Japan, required taking the focus off me, the teacher, and putting it where it needed to be—on student engagement with the lesson. I will use the six principles from that article to explain exactly what I mean by that.

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The Intellectual Engagement Principle and the Goal Principle

Previously, my lesson plans had no greater goal than to keep students busy and sometimes even entertained with the mathematics skill or concept for that day. I had come to learn, however, that those kinds of activities are not the same as intellectually engaging students in mathematical thinking. A question that every teacher needs to ask when developing any lesson plan is, What is the mathematical goal of the lesson, and how does the activity encourage thinking that leads students to achieving that goal?

Good instructional packages need solid mathematical goals. For example, it is common in exponential function units for teachers to have students do a candy or penny activity, in which a number of candies or pennies are removed according to what is visible on the surface of the coin or candy. But what is the mathematical goal of that activity? Yes, it engages students, but is it intellectually engaging, and what mathematics should the students learn by the end of the activity? What

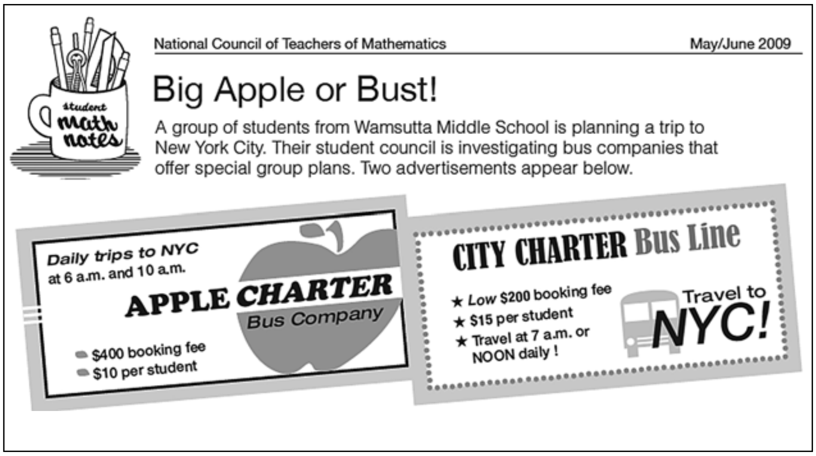

Fig. 1 A rich activity begins by engaging the students.

mathematics should we hear students discussing and see them doing as we watch and listen to them? Are they intellectually and mathematically engaged in the activity?

A few years ago, I removed the M&M's® problem from my lessons and implemented a different focus on the teaching of the exponential function, a direction that turned out to be more in line with the Common Core Standards. I have connected the teaching of the exponential function to the linear function, thus allowing students to discuss compare, and analyze the similarities and differences. Having this connection allows the exponential function lessons to flow nicely from what students already know about the linear function.

The Flow Principle

When I was looking for lessons that would engage students with rich mathematical content (I was not yet comfortable with creating these myself, nor did I have the time), Edward Nolan, then one of the editors of the *Student Math Notes* (now called *Student Explorations in Mathematics*) sent me a handful of activities that he thought might be what I was looking for.

One was a well-structured activity called Big Apple or Bust (Dixon 2009). Although a bit wordy, it had everything needed to best demonstrate the flow I had seen in Japanese lessons, and it had the goal I wanted for an introductory lesson for systems of equations. It had an engaging beginning (see **fig. 1**), connected a number of different representations, and offered a way to pull everything together in the end. At the same time, it got students thinking about the need for an algebraic equation to determine the solution to a system of equations. Most important, it started at an easy level of understanding and led students down paths of deeper mathematical thinking.

The Unit Principle and the Adaptive Instruction Principle

For all students to enter a problem or activity easily, it must have an obvious connection to topics learned in previous units and a simple-enough start that even the weakest students feel comfortable trying something.

The Preparation Principle

The preparation of a complete lesson (what I also call an instructional package) is the last of the six principles. In the Big Apple or Bust activity, students are asked to decide on transportation for a trip to New York City, and they are presented with two ads from two different bus companies, each one offering a flat rate and a price per student. The activity includes a table, on which the independent variable (number of students) increases by fives. The x-axis scale on the graph, also included, increases by tens. Because of the scales chosen in the table and graph, students are not able to state the actual point of intersection—the aspect of this activity that I found appealing. To answer the question "For what number of students would the cost of the two bus companies be the same?" students are forced to think about the meaning of the values on both sides of where the intersection value really is, both in the table and on the graph. It had never occurred to me to set the importance of the idea of finding the intersection value in the first lesson of the unit by making that intersection point not easy for them to determine. Finding the intersection required some mathematical thinking on their part, but nothing that was beyond their ability.

Because the actual intersection point is not known right away, we are able to explore other aspects of the systems topic as well. For example, I asked students to explain how they know when the cost of one company is more than the other company. The activity is very rich mathematically and did not need the large number of questions that were included in the original activity. In the activity sheet I gave out, I asked students to write an equation to represent the cost of each bus for n number of students. I wanted to know whether they could use their equations to figure out for how many students the cost of the bus companies would be the same. The rest of the original questions did not appear on the activity sheet but instead became part of my whole-class discussion.

I have used this activity for a couple of years, and the discussion generated by this activity is always rich. Students come up with many ideas about how they can find the exact number of travelers that would make the cost of the bus trips the same and often use one representation (a table or a graph) to predict the value and another

representation to check or justify their guess (the two equations). They offer sound mathematical arguments for which bus company would be better if a large, or small, number of students travelers were going on the trip. A whole-class conversation also revealed that the wording of my question—"Which would be the most economical?"—is not always going to give the same or most obvious answer for all students. For some students, a cheaper cost is not necessarily the most desirable company to go with, and that is a bias that developers of mathematics tests would need to be aware of.

A CHANGE IN FOCUS

Lessons do not have to be fancy. In a recent unit, students learned to graph a piecewise function by first drawing the entire graph and then erasing the portion of the graph that was not in the domain. When I was confident that they understood the importance of the domain aspect of the function, I reversed the process; I gave them a graph of a piecewise function and asked them to write the equations and corresponding domains for each section of the function. I knew that they could do it, but they would have to think backward, and some did struggle with that. But my students now sit in groups of three or four, which I rearrange from time to time to make sure that they are working effectively, while I move among them to hear their conversations and observe their work.

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Change does not happen easily or quickly. I have made important changes, and now my focus is on what my students are doing and thinking mathematically. The focus is no longer on me and the mathematics that I think that I have to explain to students. Rather, it is on the students and the mathematics that they learn in the problems I select for them to work through. My lessons have a single mathematical goal that is connected to previous mathematics concepts, thus providing students a place to enter the problem comfortably. And I now look forward to seeing scores on the large-scale tests that my students will need to take.

Becoming a more effective teacher has been a long journey but a very worthwhile one. Mathematics education in the United States is currently in a time of transition and change. It is a perfect time for changing more than just our mathematics standards.

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