chapter one

How Should Middle and High School Math Class Look and Sound?

Ms. Barker is a second-year mathematics teacher at a rural Missouri grades 6–12 combined middle and high school. As one of three math teachers, Ms. Barker will teach many of the same students as they progress through the grades and graduate. Her grade 8 prealgebra class has many students that she taught the year before. Ms. Barker likes the continuity of teaching students for multiple years, and she establishes classroom norms that support mathematical learning. She also designs and enacts instruction focused on her students' making sense of the mathematics they are learning. After each vignette, stop and reflect about particular aspects of Ms. Barker's instruction and her students' learning.

A VISIT TO MS. BARKER'S PREALGEBRA CLASS

Ms. Barker planned an introductory lesson on solving linear equations. Her goals were for her students to understand that solving an equation means finding a value for the variable(s) that—

- makes the equation "true";
- creates the same value on both sides of the equation; and
- "balances" the equation across the equals sign.

First she would have students figure out values for the variable in several different equations that make those equations true. Then she would engage her students in several writing tasks to help them articulate what it means to solve an equation, followed by a whole-class discussion around their writing. In ensuing lessons, students would develop and practice strategies to solve linear equations.

When the bell rang, Ms. Barker said, quietly, "I am ready to begin. Are you?" As the students settled into their seats and got out their notebooks, Ms. Barker directed their focus to instructions she had written on the board:

For each equation, figure out what value(s) for x makes both sides of the equation equal.

$2x + 6 = 20$

$5x - 4 = 21$

$-3x - 4 = -13$

Explain how you figured out each answer.

Ms. Barker continued, "To start today, I have written three equations on the board. Your job is to figure out what value for x makes each equation true. Stephan, what do you think I mean by 'makes each equation true'?"

Stephan replied, "I think it means that you are looking for the number that makes the equation work."

Ms. Barker said to the class, "What do you think Stephan means by 'work'?" She paused to let the students think and then said, "Who will share?"

A few hands shot up, and Ms. Barker called on Jasmine, who said, "Makes both sides of the equation equal the same value."

Ms. Barker wrote both Stephan and Jasmine's phrases on the board. "I think those are very good explanations of what you are looking for. Who has a question before we start?"

Sandi raised her hand. "Will x be the same or different?"

Ms. Barker said, "Do you mean from equation to equation?"

"Yes," Sandi replied.

"Well," Ms. Barker said, "for these equations, it will be different, but you ask a very good question. We'll talk about times when x can have the same value for lots of different equations. OK, let's get started."

STOP + REFLECT

- Why did Ms. Barker want her students to understand the meaning of a solution to an equation before she wanted them to master methods to find solutions?
- What beginning-of-class routines has Ms. Barker established with her students?
- What did Ms. Barker do at the beginning of class to focus the students on the math?
- Ms. Barker asked a question and then paused for her students to think before asking for a response. How did this practice benefit her students?

As students began working, Ms. Barker quickly scanned the room, noting empty seats. She stepped to her computer, at the back of the room, to record absences (because of assigned seating, she could readily tell who was absent). As she was doing so, Maggie came into class and took her seat. Ms. Barker finished recording absences. On the way back to the front of

the room, she stopped at Maggie's desk, stooped down so that her face and Maggie's were on the same level, and asked quietly, "Maggie, do you have a late pass?" Maggie shook her head. Before standing, Ms. Barker said, "Let's talk after class. For now, talk quietly with Shari to catch up on what we're doing."

Ms. Barker went around the room, peeking over students' shoulders as they wrote in their notebooks. Mike had little written on his paper beyond the original equations and his answers. Bending down to speak to Mike, Ms. Barker said, "If you are satisfied that these answers are correct, and that there aren't other correct answers, then I want you to think about how you're going to explain how you found your answers. I'm going to ask you to explain your reasoning when we come back together." As she walked off, Ms. Barker noted that Mike was not doing what she had asked but was instead turned around, talking to Edie. Ms. Barker reversed direction, as if walking back to her desk to get something she forgot. As she passed Mike's desk, she put her hand on his shoulder and then walked on. She was gratified to see, once she reached her desk and looked back, that Mike was again working.

STOP + REFLECT

- Ms. Barker tracked absences by using assigned-seating charts. How does this system compare with yours?
- Note how Ms. Barker handled Maggie's tardy and Mike's off-task behavior. How did she help keep the focus on the math they were learning rather than on their behavior?

Once back at the front of the room, Ms. Barker asked Mike to join her at the board. "Let's start by focusing on the first equation," Ms. Barker said while writing $2x + 6 = 20$ on another part of the board with room for more writing. She said to Mike, "Tell us what value you got for x that makes the equation true, and then help us understand how you were thinking about it."

Ms. Barker moved to the side of the room as Mike said, "Well, I just thought, I have to have a number that, when you multiply it by 2 and add 6, you get 20. I just figured out that it would be 7."

Ms. Barker said, "Is this the only value of x that makes the equation the same on both sides?" She paused for a few seconds. "Mike, what do you think?"

Mike replied, "I'm pretty sure it is, because I can't think of any more numbers that would work."

"Well, let's see what others think, too. Maybe that will help us decide whether 7 is the only value for x that works. Did anyone think about it differently?" As hands went up, Ms. Barker said, "Mike, can you run this conversation?"

Mike nodded and then chose Jill, who said, "I looked at it a little bit differently. I thought, 'I have to have a number that, when you multiply it by 2, you get 14.'"

Several students looked puzzled about what Jill had said. Before Mike could pose a follow-up question, James asked, "Wait a minute. Where'd you get 14?"

Jill asked to go to the board, and Ms. Barker said, "Of course." Jill wrote the following:

$$2x + 6 = 20 \rightarrow 2x = 20 - 6 \rightarrow 2x = 14$$

"So," Jill continued, "then I just thought to myself, 'What times 2 equals 14?'" Jill and Mike returned to their seats.

STOP + REFLECT

- Ms. Barker involved Mike in leading the discussion. How might that strategy have affected Mike's behavior and engagement with the mathematics?
- Consider Jill's equations. If Jill had no experience solving equations, how might she have explained her thinking? How did she make sense of what it means to solve a linear equation?

"That's very interesting, Jill," Ms. Barker said. "Who can explain why Jill can rewrite this equation [pointing to $2x + 6 = 20$] as this equation [pointing to $2x = 20 - 6$]?" No one answered. "OK, working with a couple of people around you, discuss what Jill did and why it makes sense." After a few minutes, Ms. Barker brought the students back together and said, "OK, who will share an idea from their group?"

Adam raised his hand and said, "Well, we just kinda thought that it just made sense, but we couldn't really explain it." Other students nodded in agreement.

Jill raised her hand and said, "Can I explain why it makes sense to me?" She continued, "I was just thinking about it like I used to in elementary school. Like, $8 + 3 = 11$, so $11 - 3$ has to equal 8. It's like a fact family thing. It's just that here, we have $2x + 6 = 20$ to start out, so one of the family members is $2x = 20 - 6$."

Ms. Barker paused to let the other students think about what Jill had said. "So, what if we started with the second equation [pointing to $5x - 4 = 21$]? Look at what Jill wrote on the board, and in your notebooks, write a 'family member' that will help us find the value for x that works." After a minute or so, Ms. Barker said, "Now, turn to your neighbor and talk about what you wrote. When you are done talking about number 2, work on the third equation."

STOP+ REFLECT

- While planning this lesson, Ms. Barker had not anticipated Jill's solution method. Ms. Barker decided in the moment to further explore Jill's method with the class. How might this decision benefit her students?
- What challenges may Ms. Barker have just introduced into her lesson?

Students began to write in their notebooks and then talk to their neighbors. "Raise your hand if you need a little more time," Ms. Barker said after a few minutes. Several hands went up. "We'll take a few more minutes, then. If you are finished, be sure you can explain your thinking." A bit later, Ms. Barker called the students back together and said, "Let's focus on equation 3. Who will volunteer to show us the 'family member' you wrote?"

Jasper said, "I will," and moved to the front of the classroom, where he wrote $-3x = -13 + 4$ on the board.

"Jasper," Ms. Barker said, "I'm a little confused. When Jill wrote her family member, she used subtraction, but you used addition. Can you explain what you were thinking?"

Jasper paused and then wrote $-5 - 6 = -11$ on the board. "See, this example is the same pattern as the original equation—something minus a positive number equals a negative number—and I know that −5 minus 6 is −11. Then I figured out a family member for this one, $-5 = -11 + 6$, which I know works. Then I just did the same thing to this equation [pointing to $-3x - 4 = -13$] and ended up with this [pointing to $-3x = -13 + 4$]. Can I finish it?" Ms. Barker nodded and Jasper said, "Then I just added and got $-3x = -9$, so x has to equal 3."

"Thanks, Jasper." Ms. Barker glanced at the clock and noticed that class had about twenty minutes left. She liked this idea that Jill had introduced to the class and thought that it would prove useful as she taught students different steps for solving equations. She wanted to look in her book to find problems for students to work on for the rest of the period, so Ms. Barker said, "While I am looking for something in the book, write an equation similar to these we've been working on and give it to your neighbor to

solve by using Jill's strategy." Ms. Barker then spent a minute looking in the textbook and then wrote on the board:

> Page 87, #1–18. For each equation, write a "family member" that would help you find a value for x that makes each equation true.

"Let's spend the rest of class working on these problems." As her students reached for their textbooks, Ms. Barker said, "I'll be walking around to check on your progress. Get to work, please."

CONCLUSION

Ms. Barker's classroom, though fictionalized, is based on our many observations of and conversations with beginning teachers. You may now be thinking, "There's no way that Ms. Barker is a beginning teacher," or "How did she learn to run class like that?" You may also be focused on the students in this classroom and thinking, "Can eighth-grade kids really think like that?" or "My kids could never figure out how to do something in math class like Jill did."

All teachers can develop practices similar to Ms. Barker's, and students of all ages and abilities can and should learn mathematics the way Ms. Barker's students are learning. Chapters 2 and 3 present ideas about learning and teaching mathematics that will help explain the decisions Ms. Barker made in planning and enacting this lesson. These ideas will underlie the suggestions in the rest of the book. We hope that these ideas will support you as you think about, plan, enact, and reflect on instruction.

STOP + REFLECT

- What might you notice if you entered Ms. Barker's room during class? You might see Ms. Barker standing to the side of the class and students at the board talking to the whole class. Or you might see Ms. Barker at her desk, looking at her computer or textbook while students worked in their notebooks. Or you might see students talking with each other in small groups. What would visitors see in your room during class? What would you be doing and where would you be standing? What would students be doing?
- Ms. Barker has established several norms and routines in her class that facilitate her students' engagement with the mathematics they are learning. Think about the norms and routines you have established. Are some beneficial to you and your students? Have some norms not been particularly useful?
- What do Ms. Barker's students understand about linear equations, and how do you know? Could observers in your class tell what your students understood?
- Describe how students interacted with mathematics in Ms. Barker's class. How do your students interact with mathematics?