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CHAPTER
4

Computational Procedures

A computational procedure is a series of steps or actions that we use when operating on numbers. For example, when we add, subtract, multiply, and divide we use some sort of procedure. Some procedures are algorithms. An algorithm, in terms of arithmetic procedures encountered in grades 1 through 8, is a generalized set of steps used to solve any problem of a particular class. Algorithms are efficient, produce accurate results, and can be used to solve many similar tasks using the same process. The regularity of the steps, known by memory by most people, allows the solver to focus his or her energies on more complex or important aspects of a mathematics problem.

It's useful for students to invent their own procedures when learning concepts and skills. Sometimes these “invented procedures” are identical to widely used algorithms. For example, the partial-sums method for solving multidigit addition problems is one that many students discover on their own: When adding $37 + 49$, they first add the tens ($30 + 40 = 70$), then add the ones ($7 + 9 = 16$), and then add the partial sums ($70 + 16 = 86$). However, other times students' invented procedures are not algorithms; they produce a correct answer for that one particular problem, but are not generalizable and do not work for similar problems.

Why Talk About Computational Procedures?

When we teach computational procedures, our goal should be student understanding as well as skill. Discussions about students' invented procedures can help teachers achieve this goal. Mrs. Parker's first-grade class has been exploring pairs of numbers that add to the sums of 5 and 10. She wanted her students to apply what they learned about these number pairs to solve a problem.

NCTM Standard:
Connections

Grade 1

After reading aloud to her class *Rooster's Off to See the World*, by Eric Carle, Mrs. Parker asked her students to work in pairs to find out how many animals went along for the trip. (On the trip, Rooster is joined by two cats, three frogs, four turtles, and five fish.) After approximately ten minutes, Mrs. Parker asked the students to explain how many animals were on the trip and how they figured this out.

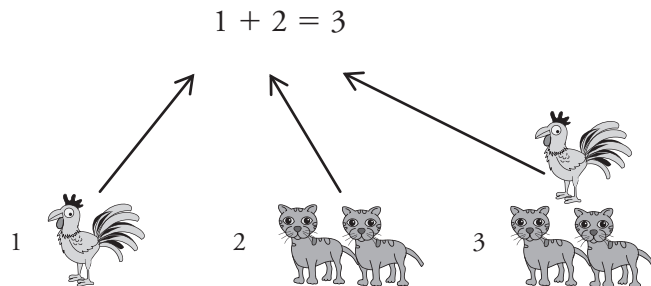
1. Caitlin: I drew a picture of all of the animals. Then I counted and got fifteen.
2. Mrs. P: So, Caitlin counted her pictures to solve the problem. Who solved it a different way?
3. Ross: I used the blocks. I took one block for the rooster, two more for the cats, three more for the frogs, four more for the turtles, and five more for the fish. When I had all of the blocks I counted them. There were fifteen.
4. Mrs. P: So Ross, it sounds like your strategy is similar to Caitlin's. You both counted animals. Is that right?
5. Ross: Yes, I counted the animals. But I used blocks. So it's different.
6. Mrs. P: So both Caitlin and Ross counted the animals, starting with one and going all the way to fifteen. One used a picture and one used blocks. They both got fifteen animals went on the trip. Is fifteen animals the answer [lots of nods]? Did anyone else solve the problem by counting?

Notice that Mrs. Parker links the two counting methods together, establishes that the answer is fifteen animals, and then surveys the class to determine how many students are counting rather than adding number pairs. Her goal in this discussion is to talk about strategies that are based on combining numbers rather than counting, but she first needs to make sure everyone understood the problem, regardless of their method. Mrs. Parker calls on a student she observed who used addition.

7. Mrs. P: Amelia, would you please share how you solved the problem?
8. Amelia: I wrote down that there were one, two, three, four, and five animals on the trip. I put the rooster and the two cats together to get three. Then plus the three frogs makes six. Then I remember that six plus four more is ten. I know ten plus five is fifteen.

9. Mrs. P: Amelia, can you tell us again what you added and I'll write the number sentences on the board?
10. Amelia: One plus two is three. [Mrs. Parker writes on the board: $1 + 2 = 3$.] Three plus three is six. [Mrs. Parker writes: $3 + 3 = 6$.] Six plus four is ten. [Mrs. Parker writes: $6 + 4 = 10$.] Ten plus five is fifteen. [Mrs. Parker writes: $10 + 5 = 15$.]
11. Mrs. P: So Amelia, can you explain to us why you were adding these numbers?
12. Amelia: Because we want to put them all together and see how many are on the trip.
13. Mrs. P: Tell me about this first number sentence. Why did you write "one plus two equals three"?
14. Amelia: There is one rooster and two cats were with him on the trip.
15. Mrs. P: Billy, can you repeat what Amelia just said about where in the story the one and the two come from in her number sentence?
16. Billy: From the rooster and two cats.

Mrs. Parker writes the following under the number sentence on the board to provide a visual scaffold for those students who used counting. This also provides students with a record of the discussed thinking.



17. Mrs. P: Why did Amelia add three plus three? [She points to the number sentence $3 + 3 = 6$ on the board.] Where did those numbers come from? Hoai?
18. Hoai: I don't know.
19. Mrs. P: Talk to the person next to you about the three plus three. What animals does each three stand for in the story?

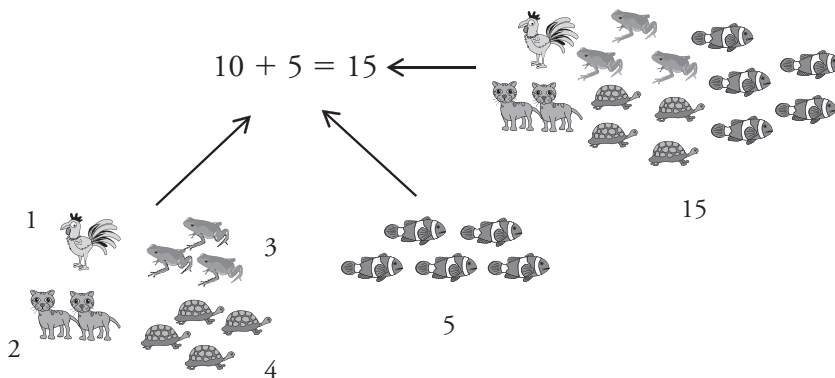
Mrs. Parker now has the students thinking about addition, but she clearly lost some children when she jumped to the second number sentence. So she

asks students to talk to the person next to them about what the numbers in this new number sentence represent. Partner talk is effective with young students when the question is very focused.

Mrs. Parker calls on three different pairs of students to share their understanding that one of the 3s represents three frogs and one of the 3s represents the rooster and cats together. She adds pictures of the animals underneath the number sentence. She does not worry about the order of the labels. The last pair of students she calls upon includes Hoai.

- 20. Mrs. P: So Hoai, you're saying that the rooster plus two cats makes three, then three more frogs make six animals in all? [She points to the numbers in the number sentence as she says this. Hoai nods.] That makes sense to me. Who can tell me where Amelia got the numbers for the next sentence?
- 21. Pete: There are six so far, then four more come, the turtles, so that's ten. Then five fish come, and that's fifteen.
- 22. Mrs. P: Talk to the person next to you about what Pete said. What animals does the six stand for? What animals does the four represent?

Following this, Mrs. Parker then establishes the meaning of Amelia's number sentence, $10 + 5 = 15$, by asking students to talk about each of the numbers. The final number sentence has pictures of the animals written under it.



She then summarizes what they had talked about.

- 23. Mrs. P: So let's look at Amelia's method. Amelia solved the problem by adding two numbers at a time. She started by adding one plus two and then took that answer, which was the total

number of animals so far, and used it to keep adding. [Mrs. P writes on the board, $1 + 2 + 3 + 4 + 5$.] Could Amelia have started with a different pair of numbers? Vanessa?

24. Vanessa: Yes, we played that game and one of the pairs was four plus one is five. So that's five. Then there's another five and that's ten. And then there's three plus two, which is another five. That's fifteen.
25. Mrs. P: Vanessa, you said a lot. Let's back it up a little. What do you mean by "that game"?
26. Vanessa: The game where we looked for numbers that add to five. One of them was four plus one and another was two plus three.
27. Mrs. P: Are you thinking of the Sum Five game where we shake a cup and add beans to make five? Who else remembers that game? [Students nod.]

Mrs. Parker helps students connect to prior knowledge by jogging their memory about a previous experience in order to help them build upon existing knowledge. She also reintroduces the vocabulary word *sum*.

28. Mrs. P: What numbers did we discover have a sum of five?
29. Students: Four and one.
Two and three.
Zero and five.
Three and two.
30. Mrs. P: Who can explain how using numbers that add to five will help us solve the problem?
31. Kevin: The rooster and four turtles make five; the five fish is five. The two cats and the three frogs make five. There are lots of fives!
32. Leia: Like, we can make fives a lot. And it's easy to add fives since they make ten.
33. Mrs. P: Work with your partner and add these numbers from the problem. [Points to $1 + 2 + 3 + 4 + 5$.] Look for numbers that make five. What is the answer when you add these numbers? How many animals went on the trip?

By focusing the discussion on the meaning of the numbers in the number sentences in the context of the story problem, Mrs. Parker is helping her students understand addition. But she is also helping them learn number facts. She asks them questions that focus on facts to make five and then has them