Breanna Counts by Tens to Solve a Word Problem Involving Groups of Tens

This story is a part of the series:

***What's Next?* Stories of Teachers Engaging in Collaborative Inquiry Focused on Using Student Thinking to Inform Instructional Decisions**

What's Next?

Stories of teachers engaging in collaborative inquiry focused on using student thinking to inform instructional decisions

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Introduction

This lesson focuses on students' solving a multiplication problem that lends itself to using base-ten thinking. The lesson was presented toward the beginning of second grade in an effort to determine students' understanding of base-ten concepts.

Relevant Florida Mathematics Standards

MAFS.1.NBT.2.2 Understand that the two digits of a two-digit number represent amounts of tens and ones.

a. 10 can be thought of as a bundle of ten ones — called a "ten."
b. The numbers from 11 to 19 are composed of a ten and one, two, three, four, five, six, seven, eight, or nine ones.
c. The numbers 10, 20, 30, 40, 50, 60, 70, 80, 90 refer to one, two, three, four, five, six, seven, eight, or nine tens (and 0 ones).
d. Decompose two-digit numbers in multiple ways (e.g., 64 can be decomposed into 6 tens and 4 ones or into 5 tens and 14 ones).

MAFS.2.NBT.1.1 Understand that the three digits of a three-digit number represent amounts of hundreds, tens, and ones; e.g., 706 equals 7 hundreds, 0 tens, and 6 ones. Understand the following as special cases:

a. 100 can be thought of as a bundle of ten tens — called a "hundred."
b. The numbers 100, 200, 300, 400, 500, 600, 700, 800, 900 refer to one, two, three, four, five, six, seven, eight, or nine hundreds (and 0 tens and 0 ones).

MAFS.3.NBT.1.3 Multiply one-digit whole numbers by multiples of 10 in the range 10–90 (e.g., 9×80, 5×60) using strategies based on place value and properties of operations.

Background Information

This investigation was strongly informed by chapters four and six in *Children's Mathematics: Cognitively Guided Instruction* (Carpenter et al., 2015). These chapters provide background on multiplication and division problem types as well as strategies that students use to solve these types of problems. In addition, chapter six provides some background information on base-ten number concepts.

Consider reading p. 163 in *Elementary and Middle School Mathematics: Teaching Developmentally* (Van de Walle et al., 2010). This page explains the importance of encouraging students to think about the meaning of a problem instead of relying on key-word strategies.

Carpenter, T. P, Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (2015). *Children's Mathematics: Cognitively Guided Instruction (2nd Ed.)*. Portsmouth, NH: Heinemann.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. (2010). *Elementary and Middle School Mathematics: Teaching Developmentally (Seventh Edition)*. Boston, MA: Pearson Education.

Analyzing Student Thinking

The following set of problems was given to a class of second-grade students in one-on-one interviews. A group of teachers interviewed each student in the class individually in order to form a good understanding of each student's mathematical thinking on that day. The intent of the sequence of problems was to provide insight into how these students approached multiplication and division word problems. The interviewer had the flexibility to skip any problem that seemed to cause undue stress to the student. The students had access to linking cubes, base-ten blocks, and writing materials and were given the choice to use whatever method made the most sense to them. Each item was read aloud to each student by the interviewer and reread as needed. After the student provided an answer, the interviewer asked the student to explain the strategy used to solve the problem.

A. I have 5 boxes with 6 cookies in each box. How many cookies do I have?

B. I have 8 boxes of pencils with 10 pencils in

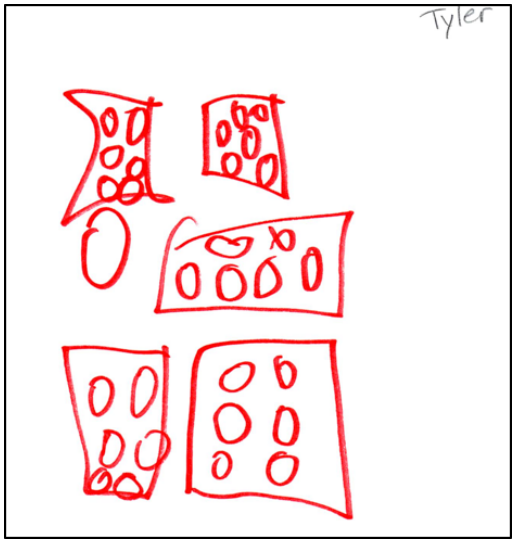

Figure 1. Tyler's student work for Problem A.

each box. How many pencils do I have?

C. The second graders at Orange Grove School raised $67 to buy books for the children's hospital. If each book costs $10, how many books can they buy?

After the students solved the three problems, the teachers sorted the students into the strategy categories described in the following paragraphs.

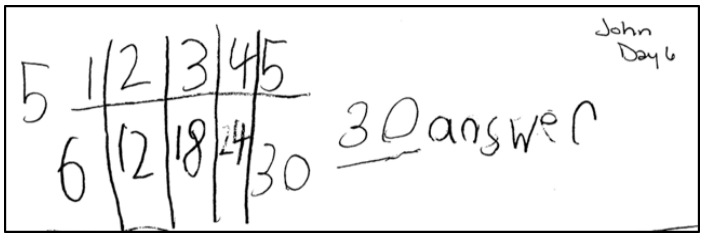

Figure 2. John's student work for Problem A.

Types of Multidigit Strategies[1]

Students who use a *counting by ones* strategy represent all the quantities in the problem and count by ones to determine the solution. In the Problem B, the student would model eight groups with ten in each group. The student would then start counting at 1 and count all the way to 80 by ones.

Students who use a *counting by tens* strategy represent all the quantities and count by tens and ones, keeping track with manipulatives or drawings (including fingers). In problem B, the student would model eight groups with ten in each group, then would then start counting at ten and count all the way to 80 by tens.

Students who use a *counting* strategy do not rep-

1 The descriptions of strategies presented in this section are the current descriptions used by our team, and we consider them to be fluid, as our understanding of these ideas continues to evolve. For a more detailed discussion of these terms consider reading Carpenter et al. (2015).

Could not solve	Counting by ones	Counting	Known facts
Gracie	Tyler	Jayme	Kevin
Haylee	David	John	Talan
Trenton	Alexis		Jeremiah
Selena	Jason		
	Aubrey		
	Adrienna		
	Lilli		
	Aiden		
	Olivia		
	Brice		
	Carleigh		

Figure 3. Teachers' Classification of Students' Strategies for Problem A

resent each quantity in the problem. For Problem B, the student would count out loud by ten eight times or write the numbers 10, 20, 30, 40 50, 60, 70, 80.

Students who use a *direct place value* strategy know how many tens and ones are in the given number and provide the answer without modeling or counting. In problem B, the student would quickly say "80" and explain that he or she knows that eight tens make 80.

Student who use a *known fact* strategy recall the answer from memory or respond that they "just know" the answer. In problem B, the student would quickly answer "80" and say they know that 8×10 is 80.

Strategies Used by Students in This Class

After interviewing students, the teachers discussed at length the strategies they observed students using to solve the three problems. The teachers identified the following categories as general groups into which they would place the students.

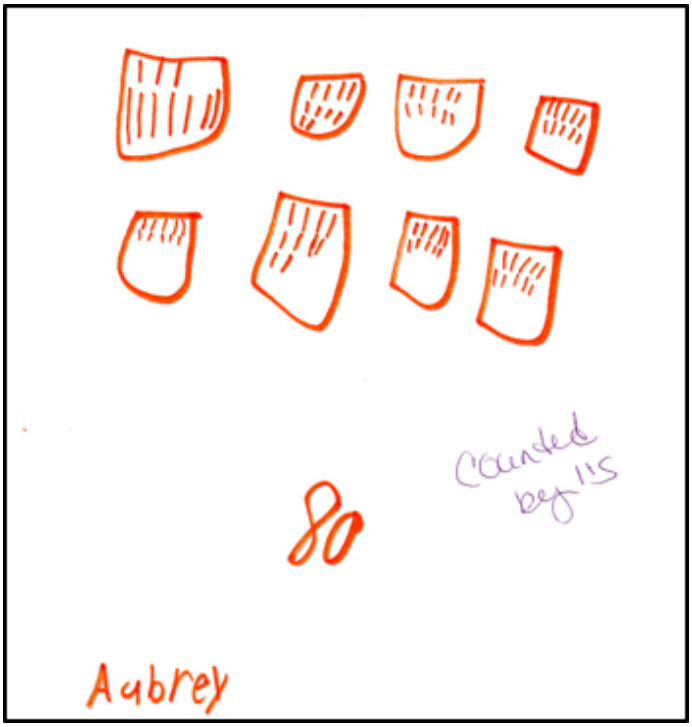

Figure 4. Aubrey's work for Problem B.

Problem A: *Could not solve, counting, known facts*

Problems B and C: *Could not solve, counting by ones, counting by tens, and direct place value*

Figure 1 shows the work of a student named Tyler who used a *counting by ones* strategy. Tyler made five groups and drew six circles in each group. He then correctly counted each circle by ones and said that the answer was 30.

Figure 2 shows how a student named John notated his *counting* strategy. John counted by sixes to find the answer to the problem. As shown in his work, he made columns for each "group," and as he was counting, he wrote the total number counted thus far in each column—two groups contain 12, three groups 18, and so on.

Figure 3 shows how the teachers sorted the strategies exhibited by the students in this class on Problem A.

Figure 4 is an image of work created by a student named Aubrey as he tried to solve Problem B. Aubrey used a *counting by ones* strategy to model the situation in the problem as shown in Figure 4. After placing ten tick marks in each of the eight boxes he had created, Aubrey went back and counted each mark by ones (and did not count by groups of ten).

Figure 5 shows another student named Lane's work for Problem B, as well as notation of how he counted to determine his answer. Lane used a

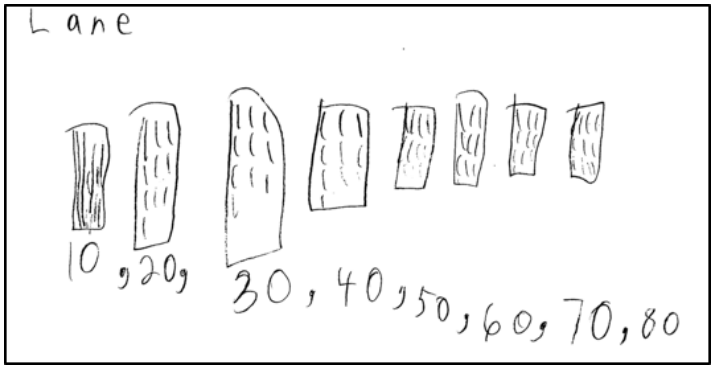

Figure 5. Lane's work for Problem B.

counting by tens strategy to model the situation in the problem, as shown in the figure. After placing ten marks in each of the eight boxes, he went back and counted the marks by tens rather than counting the individual marks by ones.

Figure 6 shows the teachers' classification of student strategies on Problem B.

Figure 7 shows a snapshot of the way the students in the class solved Problem C. An "x" indicates that the student arrived at an incorrect answer.

The teachers discussed these classifications at length and noticed many things about the class and about the individual students. For example, four students did not solve any of the three problems correctly. Some of these four students simply added the two numbers from the problems together regardless of the story or context of the problem. The practice of teaching key words was discussed, and teachers raised concerns about how the practice may be inhibiting students' understanding of the situations presented in word problems and cause them to respond in ways that do not make sense in the context of the problem.

In examining the student responses for Problem B, the teachers noted how many students still used *counting by ones*, even though ten and ones has already been discussed during the current school year.

Setting Learning Goals for These Students on This Day

On the basis of how the students solved Problems A and B, the teachers determined the following two goals for the lesson:

> *1. Pose a multiplication word problem with simpler grammar and vocabulary words to aid students who are struggling to understand the problem situation.*
>
> *2. Pose a multiplication problem involving tens that might encourage students to use strategies that reflect an understanding of tens.*

The teachers decided that they should develop a problem that would help struggling students to understand the situation in the problem. Because language might be a barrier, the teachers thought that using simpler words could be beneficial.

The teachers also thought that posing a problem that includes groups of ten in the problem situation would pave the way for students to seize the opportunity to *count by tens* or use *direct place value* strategies. Doing so provide insight into students' place value understanding and potentially provide some teachable moments.

Planning for the Lesson

The teachers worked to develop a problem for students that would use simple language and a familiar context. Discussion addressed the number choices that would allow students to think about the concept of grouping by tens. Three different ideas emerged about the best numbers to use: (2, 10), (7, 10), and (15, 10). Although (2, 10) was not actually used during the lesson, the teachers did decide to use (3, 10) to introduce the

Could not solve	Counting by ones	Counting by tens	Direct place value
Gracie	Tyler	Kevin	John
Trenton	David	Jason	Jalan
Haylee	Jayme	Lane	Jeremiah
Selena	Alexis	Talan	
	Audrey	Adrienna	
		Carleigh	

Figure 6. Teachers' Classification of Students' Strategies for Problem B.

Could not solve	Counting by ones	Counting by tens	Direct place value
John	Lilli (x)	Jason	Kevin
Alexi	Olivia (x)	Talan	Jeremiah
Gracie	Aiden (x)	Lane	Talan
Jayme	Tyler (x)	Adrienna	Carleigh
David	Brice (x)		
Tyler			
Selena			
Trenton			
Audrey			
Haylee			

Figure 7. Teachers' Classification of Students' Strategies for Problem C.

lesson. The teachers eventually settled on the following problem:

> *There are ___ cups on the table. The teacher put ___ Skittles in every cup. How many Skittles are there?*

The hosting classroom teacher wanted to give the students three different number choices and allow the children to decide which number sets to use to determine their own level of challenge. All students would first begin with the numbers (3, 10). Once they were successful with the numbers (3, 10) during the lesson introduction, students could attempt more advanced number combinations, like (7, 10), (11, 10), and (15, 10).

Rationale for the problem selected

The teachers believed that this problem would allow students the opportunity to group and *count by tens* or to use *direct place value* strategies. It would also provide the teacher with additional opportunities to learn how their students were thinking about multiplication problems involving groups of ten.

Strategies for differentiation to meet the needs of all students in the class

To meet the needs of the students who were unable to solve any of the problems correctly in the initial interviews, the hosting classroom teacher planned first to read the problem aloud to the whole class while students read aloud with her. She then planned to break the problem apart into sections and have conversations with the students about the meanings of each part of the story.

For students who finished quickly and were successful with the numbers (11, 10), the teacher planned to challenge them with the same problem but change the numbers to (15, 10) and, beyond that, to even higher numbers. The students would also be allowed to choose among the additional number choices available, so that all students would appropriate levels of difficulty. Because students had no prior experience choosing numbers when solving a problem, the teacher planned to discuss with them the process of choosing numbers that were neither too hard nor too easy.

While students worked independently on solving the problem with the initial set of (3, 10), the teacher planned to circulate and to monitor those students who had struggled during the initial interviews. The teacher planned to ask these students to read the problem aloud with her again and discuss the action in the problem. The teacher planned to ask probing questions as needed to help students to make sense of the problem but did not intend to model it for the student or provide suggestions for strategy use. Instead,

the teacher wanted students to grapple with the problem and use the strategy that made the most sense to them once they were able to explain the action in the problem.

Notes on what to notice about student thinking during implementation of the lesson

In addition to monitoring those students who had previously struggled to solve multiplication grouping problems, the teacher planned to watch for students who were *counting by ones*, *counting by tens*, or using *direct place value* strategies. She would take notes and use these observations to decide which students to ask to share their thinking with the rest of the class.

Lesson Plan

In planning for this lesson, the teachers developed the following learning goals:

1. *Pose a multiplication word problem with simpler words for students struggling to understand the problem situation.*

2. *Pose a multiplication problem involving tens that may encourage students to use strategies that reflect an understanding of tens.*

Lesson Plan Instructions

1. Say to the class:

   a. I am going to ask you to work really hard today.

   b. When you are solving a math problem, I want you to think about how you are thinking of the problem and I want you to write how you were thinking on your paper.

   c. We will have a few students come up and share their thinking.

2. Call the students together for a group session in a place that is convenient for all students.

3. Display the following problem for students.

   There are ___ cups on the table. The teacher put ___ Skittles in every cup. How many Skittles are there?

   Do not give the numbers in the problem to the students yet. Leaving the number spots blank provides an opportunity to focus on the meaning of the problem with those students who struggled to make sense of the earlier problem.

4. Ask students to read along while you read the problem aloud.

   "There are ____ cups on the table. What does that sentence mean? What do we know?"

   If students are unable to explain accurately the meaning of the first sentence, continue the conversation as needed.

   Read the next sentence in the problem aloud in chorus with the students.

   "The teacher put ___ Skittles in every cup. Do you know what Skittles are? What do we know about what is happening in this sentence?"

5. Explain to students that today everyone will begin with the same set of numbers for the problem. After they solve the problem with the first set of numbers, they may choose another set of numbers and solve it again."

6. Say to the class, "Not only am I going to ask you to think about the problem, I want you to put what you think on paper." Then write the numbers 3 and ten in the blanks of the problem that is displayed. Hand out paper copies of the problem with white space students could use to record their thinking. Write the numbers (3, 10) beforehand in the blanks of the handout for the students, and add the numbers 7, 10, and 15 below the problem so that students can choose from these numbers later in the lesson.

7. Then dismiss the students back to their seats to begin working on recording their thinking. Students should have access to manipulatives including base-ten blocks and linking cubes.

8. While students work independently on solving the problem with the initial set of (3, 10), circulate and monitor those students who had struggled earlier. If such a student is still struggling, pause and have him or her read the problem aloud and discuss the action in the problem. Ask probing questions as needed, such as, "Are there tools you could use to show what is happening in the story problem? or "Can you show me on your paper what is happening in the story problem?"

9. As students successfully solve the problem with the number set (3, 10), encourage them to pick another number set to solve the same problem, for example (7, 10), (11, 10), or (15, 10). In addition to monitoring the struggling students, and make note as you circulate of students' strategies with all four number sets. Select six students who used different strategies. Look for students who count by ones, count by tens, and use *direct place value* with the problem.

10. Call students back to the gathering area and have them bring their work (if students wrote it down). Remind students of behavior expectations on the floor (rug).

11. Say to the class, "You just solved a problem, and different students used different strategies to do that. We are going to look at the problem you solved, and some of you will get to share your thinking so that we can hear more about how you did it. Why do you think we want you to share your solutions and strategies? What could be one reason?"

12. Encourage students to think and share their reasons.

    "Think about how you solved the following problem."

13. Display the problem for students to see.

    There are 3 cups on the table. The teacher put ten Skittles in every cup. How many Skittles are there?

14. Explain to the class that only six students will be asked to come up and share, but everyone else also has a job, because everyone needs to be an active listener.

15. Call the chosen students one at a time to share their strategies at the board. As students share, listen for opportunities for other students to come up and help the sharing student if he

Conversation with students revealed that they thought drawing by ones was too much work with the number choices (11, 10) and (15, 10) and realized that they could just use tens.

or she is struggling. This process will provide opportunities for students to learn from and help each other. For examples, refer to those given in Phase 5: Reflection. Call students up in order from least sophisticated strategy used to most sophisticated.

Transcript and Examples of Student Work Generating During the Lesson

Teacher: *I wonder how many different strategies we will have for this problem.*

Gracie was asked to come up to the screen to share her strategy. Figure 8 shows Gracie's work.

Teacher: *Gracie, I want you to come up because you really had to work through this. Gracie will you put that underneath the camera? I want you to talk about your work.*

Teacher: *What was the first problem about?*

Gracie: *Skittles in cups.*

Teacher: *Gracie can I tell your story? After receiving permission from Gracie, the teacher continued. When Gracie first started working through the problem she added 3 + 10. But when she read the problem again she realized that wasn't right. Gracie, can you explain what you did?*

Gracie proceeded to draw ten dots on her paper.

Teacher: *How many is that?*

Gracie: *ten.*

Teacher: *What is the ten about in the problem?*

The entire class was then directed to turn and talk about where the ten is in the problem. After a very short pause, the students were redirected back to Gracie and the teacher. Students were given an opportunity to respond to each of the following questions.

Teacher: *Does Gracie has one cup or more than one cup?* (Gracie initially had only drawn one cup.) *What does she know about the next cup?*

Teacher: *So Gracie can you make another cup?*

Gracie drew 20 more dots.

Teacher: *Does anyone see another cup that could have ten? What does she need to do?*

Gracie drew an oval around another set but made a mistake with her counting and actually circled more than ten. The teacher asked Gracie to recount her dots and Gracie corrected herself.

The teacher asked another student to come forward and tell how he thought about counting Gracie's picture (The teacher had already noted that Gracie counted her picture by ones). The student said he counted each circle by tens.

Teacher: *Gracie, will you do that again and invite your friends on the carpet to do that with you.*

Teacher: *Students, we can count this by tens or*

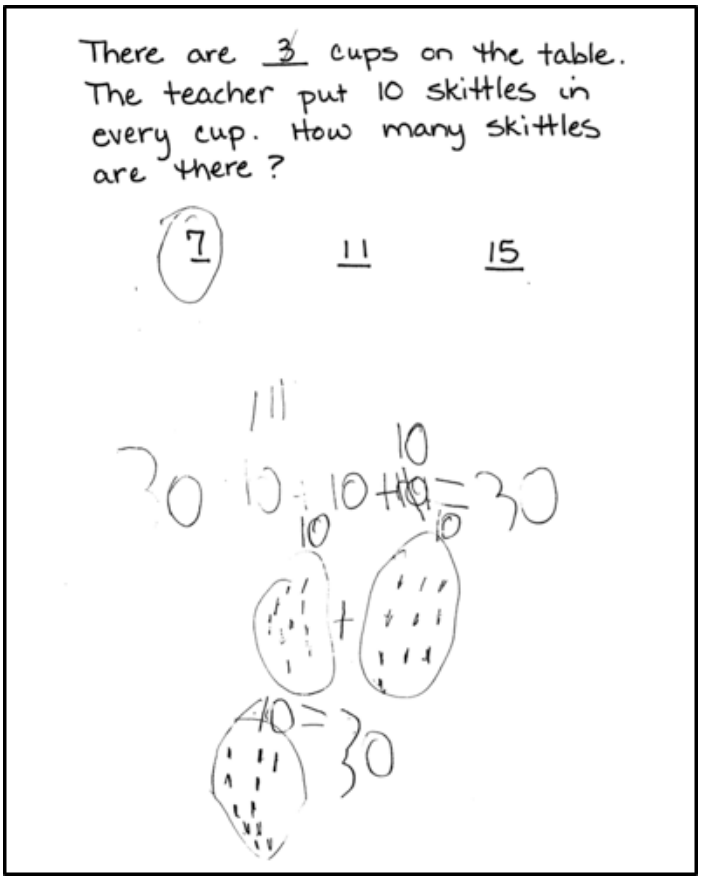

Figure 8: Gracie's student work for the initial Skittles problem.

by ones. Which do you think would be the most efficient?

After students responded, the teacher thanked Gracie, and she sat down.

The teacher then asked Jason to come up and share his strategies. Figure 9 shows Jason's work and the interaction with Jason explaining his thinking.

Teacher: *Jason, how did you think about this problem?*

Jason: *I counted 10, 20, 30.*

Teacher: *But did you have to draw a picture?* Jason nodded his head.

Teacher: *Students, how many drew dots? How many made boxes and put dots in the boxes?*

Students: *It is a lot of work to draw so many dots.*

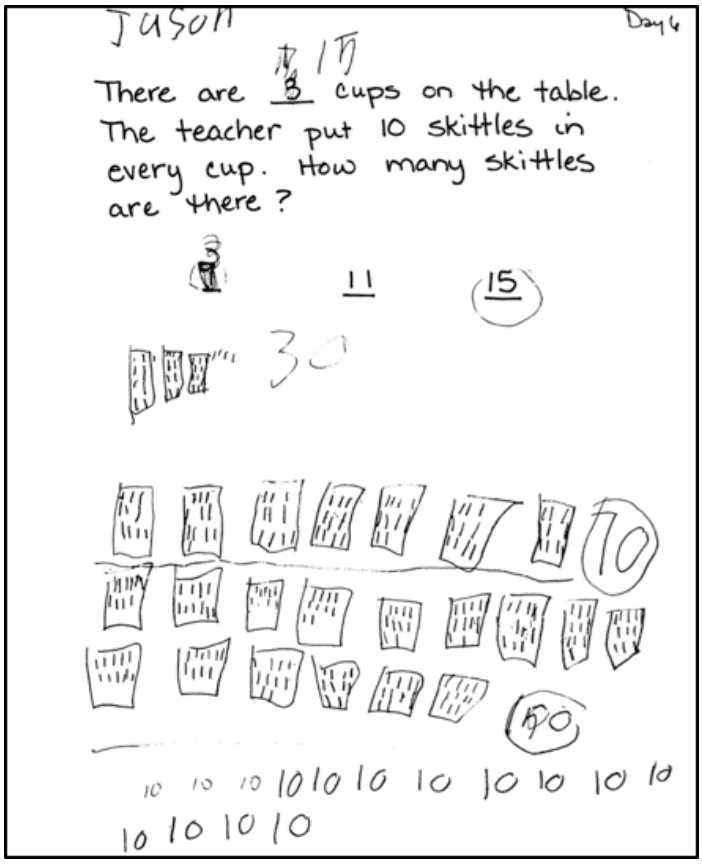

Figure 9: Jason's student work for the initial Skittles problem.

Teacher: *What is a lot of work to draw the dots?*

There was a brief discussion about drawing dots and keeping track of counting.

Teacher: Let's look at Jason's work. He even drew dots with 15 and 10. Isn't that a lot of work?

Jason was then asked to explain why he wrote the ten's across the bottom of his page.

Jason: *When I counted in the last problem (15, 10), I counted each group of ten by tens.*

Teacher: *Can you explain why you counted by tens?*

Jason: *Because each group had ten, I could count by ten a lot faster than counting by ones.*

Jason was thanked for explaining his thinking and asked to sit back down.

The teacher then asked Alexis to come to the screen to share her strategy. Figure 10 shows Alexis' work.

Teacher: *Alexis how did you count when you solved with the numbers (15, 10)?*

Alexis: *I counted by ones.*

Teacher: *Can you recount your picture using a similar strategy to what Jason just said?*

Alexis was given time to work through recounting her picture by tens and finally determined the correct answer.

Breanna was then asked to come up to the screen to share her strategy. Figure 11 shows Breanna's work.

Teacher: *Breanna, can you explain how you solved the problem with the numbers seven and ten?*

Breanna: *I drew seven boxes with ten in each box.*

Teacher: *Can you explain how that strategy is dif-*

ferent from how you solved the problem with the numbers (15, 10)?

A discussion followed with Breanna explaining that she realized that she did not want to draw ten dots in all 15 boxes because that would take so much time. So she decided to instead just write ten in each box and then count by tens to get her answer.

Teacher: *Let's look at David's work.*

The teacher shows Alexis' and David's work side-by-side.

Teacher: *How are these related? (Referring to the seven groups of ten in both samples of student work)*

Teacher: *How many groups of ten does David have here?* (Pointing to the seven boxes David drew above 10 + 10 + 10 + 10 + 10 + 10 + 10 = 70)

Teacher: *David, look here* (10 + 10 + 10 +, ….). *How are these related?*

Teacher: *Students, how many tens do you think he has here? (How many groups of ten?)*

Teacher: *David and Breanna both showed seven groups of ten. At some point David found out it is easier just to write 10 + 10 + 10 + 10 + 10 + 10 + 10 = 70. Why would I want to do 10 + 10 + 10 + 10 + 10 + 10 + 10 instead of drawing a picture?*

Teacher: *If I count by tens ten times, how much will I get? Turn and talk to the person next to you. Do you know what ten tens is?*

The last person to share his thinking for the lesson was Kevin. The following is an image of Kevin's work and the interaction with Kevin explaining his thinking.

Teacher: *You know how everyone thinks differently? Let's listen to what Kevin was thinking while he solved the problem. Kevin you had a lot in your head when you solved the problem.*

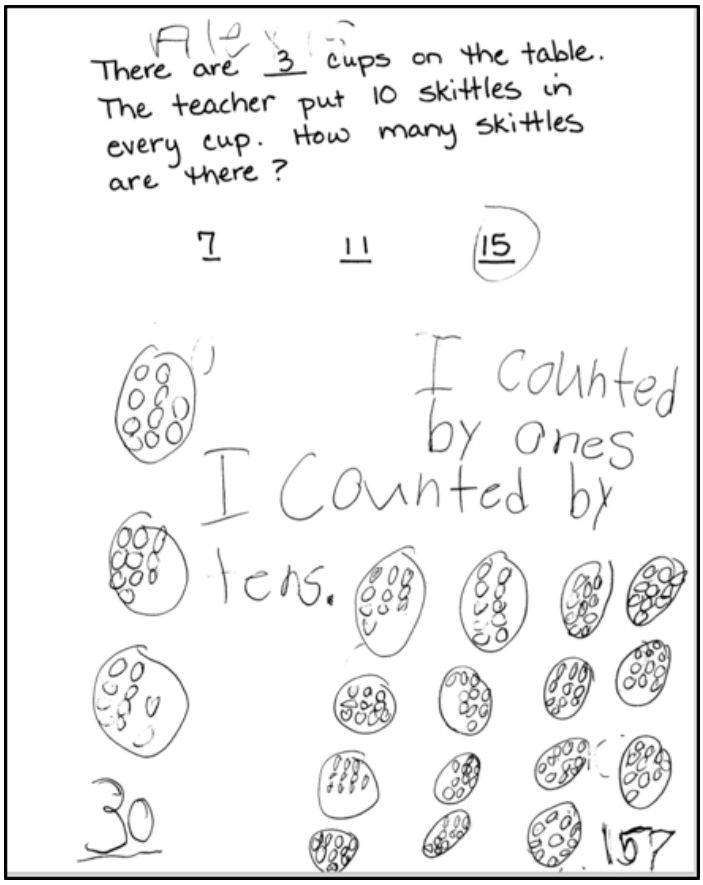

Figure 10. Alexis' student work for the initial Skittles problem.

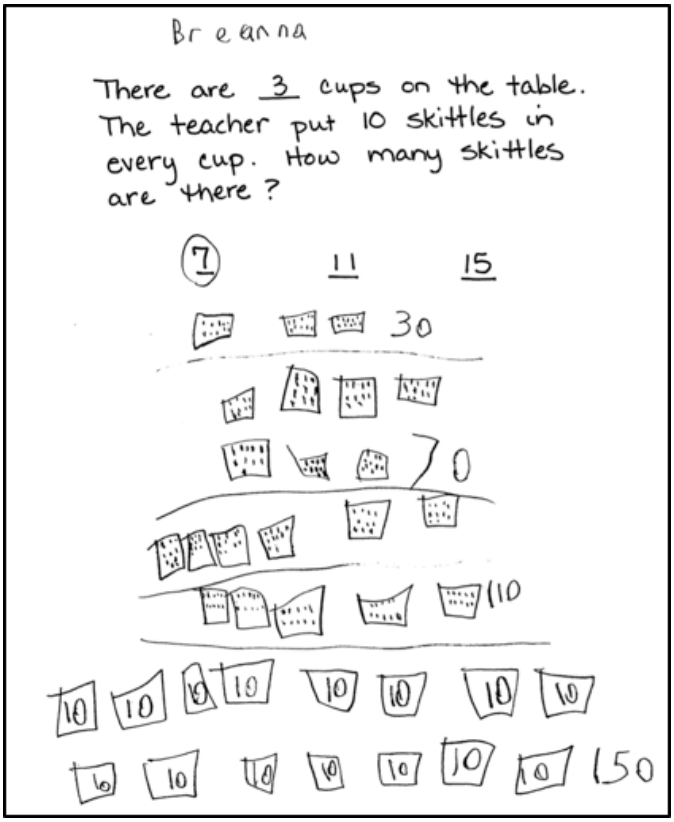

Figure 11. Breanna's student work for the initial Skittles problem.

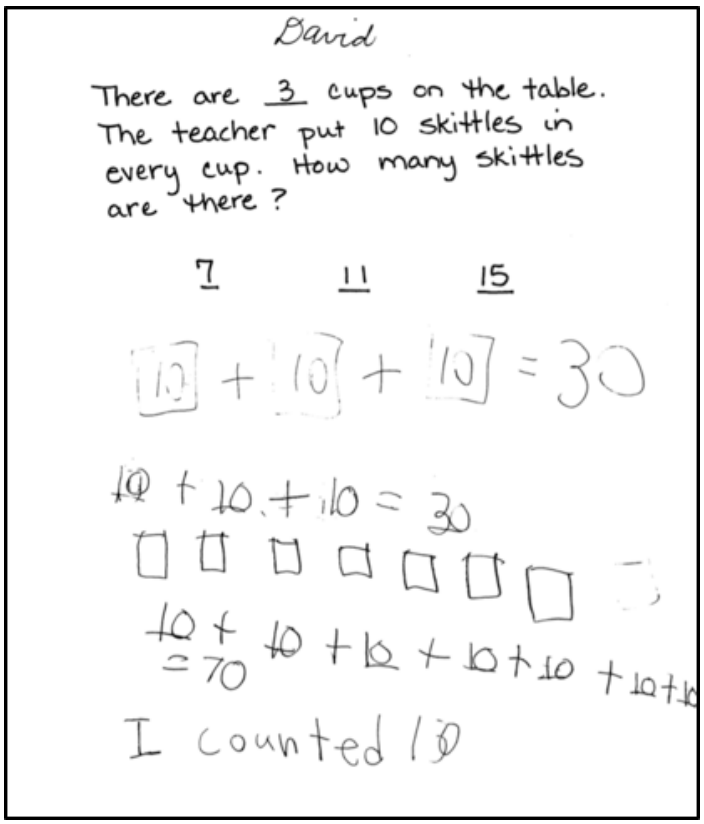

Figure 12. David's student work for the initial Skittles problem.

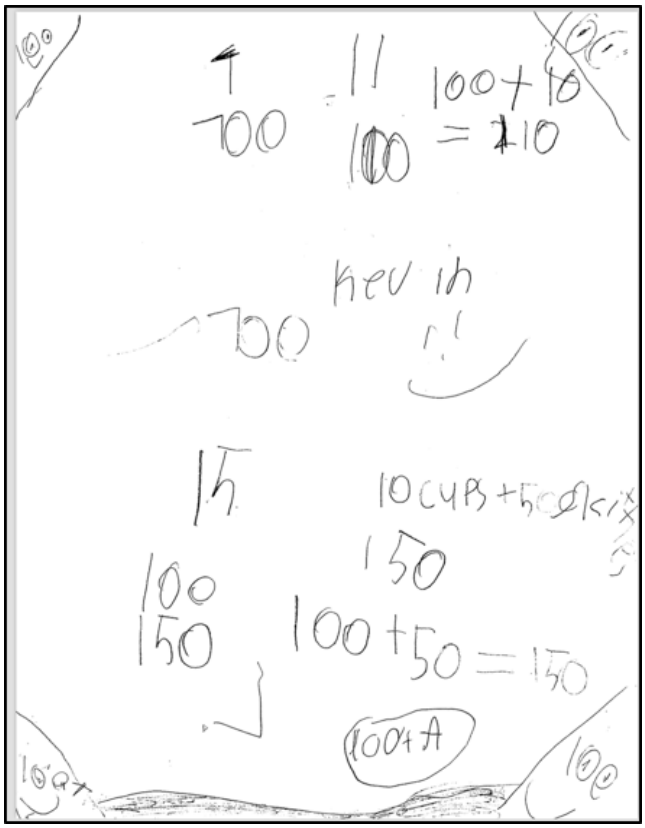

Figure 13. Kevin's student work for the initial Skittles problem.

Kevin then began to explain how he was thinking of the problem with (15, 10).

Kevin: *I knew something about tens.*

Teacher: *What did you know about tens?*

It was difficult for the student to articulate his thinking so the teacher followed up with the following questions.

Teacher: *How many tens did you have? Did you know something about five tens?*

Kevin: *50.*

Teacher: *What is another name for two tens? What is another name for five tens?*

Kevin was coming to understand using *direct place value* to explain that in the number 150 there are 15 tens and 150 can be thought of ten tens which is 100 and five tens which is 50, so the answer would be 150.

Reflection

Notes and observations from the enactment of the lesson

During the sharing portion at the closing of the lesson, a student had used a valid strategy, but she miscounted. The teacher provided an opportunity for the student to correct herself.

Several students wanted to explain a strategy that was different from the ones that they had actually used to solve the problem.

Most students used at least two of the additional number choices after being successful with (3, 10). Interestingly, some students used *counting by ones* initially with smaller numbers but switched to more sophisticated strategies when attempting to find the answers to (11, 10) and (15, 10). Conversation with students revealed that they thought drawing by ones was too much work with the number choices (11, 10) and (15, 10) and realized that they could just use tens.

During the initial interviews, Gracie, Trenton, Haylee, and Selena were unsuccessful with both multiplication grouping problems. With support from the teacher to help them make sense of the problem, Gracie, Selena, and Haylee were able to solve the problem successfully with (3, 10). Trenton was not successful even with multiple attempts to reread to make sense of the problem. He was therefore given the following problem to solve instead.

> *Trenton has 12 cookies. His friend Michael gave him 9 more cookies. How many cookies does he have?*

Trenton was not successful with this problem either, so he was given the following problem.

> *Trenton has 6 cookies, and he ate 6 cookies. How many cookies are left?*

Trenton was successful solving this last problem.

The students were unfamiliar with using manipulatives, and manipulatives were not initially readily available. Despite this context, most students used direct modeling strategies to solve the problems.

Using the larger numbers, Alexis changed from *counting by ones* to *counting by tens* during the lesson. David also shifted to a more sophisticated strategy; he was consistently *counting by ones* in the initial interview.

Ideas for the next lesson(s)

The students therefore need opportunities to explore how to use tools (e.g., counters, base-ten blocks, and linking cubes) appropriately. Explicit instruction on using the tools for the purposes of math and not as toys may be necessary, depending on how students respond to the opportunity to use them with mathematics problems.

Future lessons should include opportunities for students to continue to explore solving multiplication grouping problems with two-digit numbers in which students represent the number in each group as a ten instead of by ones. Students should be provided opportunities to count by tens with the intention of helping them move away from solely *counting by ones*. Once students are moving along into more sophisticated strategy use with multiplication grouping problems, measurement division problems with numbers can be given to encourage students to use *direct place value* understanding.

What's Next?

Stories of teachers engaging in collaborative inquiry focused on using student thinking to inform instructional decisions

What's Next? is a collection of stories documenting professional development experiences shared by elementary teachers working collaboratively to study the complex process of teaching and learning mathematics. Each story in the collection describes practicing teachers studying the thinking processes of real students and using what they learn about those students to make decisions and try to help advance those students' understanding on that day.

The teachers in each story start by learning about how individual students are solving a set of mathematics problems. They use this freshly gathered knowledge of student thinking to develop near-term learning goals for students and a lesson plan tailored to specific students on that specific day. One of the teachers implements the planned lesson while the other teachers observe in real time. The teachers then gather to discuss and reflect on their observations and insights.

In these lessons, the practice of teaching is slowed way down. The stories tell of teachers who are studying student thinking and using that information to plan and implement instructional decisions at a pace that is much slower than it occurs in daily practice. The stories in this collection also depict many aspects in common with formative assessment and lesson study, both of which are a process and not an outcome.

The stories depict real situations that occurred in real time and include both successes and shortcomings. We hope that the stories may be studied and discussed by interested educators so that the lessons and ideas experiences of these teachers and instructional coaches may contribute to additional learning and sharing among other interested teachers.

Learn more about these and other stories at **http://www.teachingisproblemsolving.org/**