Using Number Talks to Build Procedural Fluency through Conceptual Understanding

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Abstract: *Effective mathematics instruction needs to provide opportunities for students to build procedural fluency through conceptual understanding. Number Talks provide a brief, daily opportunity for students to discuss, connect and develop their strategies for solving problems. Through these activities students will develop fluency from a deeper level of understanding.*

Keywords: *Discourse, problem solving, conceptual understanding*

1 Introduction

Too often, I hear that students do not have number sense or fluency with facts. It's likely that many of us have encountered a middle school student who grabs a calculator to compute 7×2 or a high school student who presses buttons to determine, without hesitation or a second thought, that -3 squared is -9. I know these students know better; I have encountered 3rd grade students using arrays and equal groups and repeated addition to find the value of 7×2; I have observed 7th graders who understand conceptually that a product of two negative numbers is positive. I truly believe all students have the capacity to understand the aforementioned problems. Why, then, do students appear to be unaware of their facts or have little number sense as they grow older? I believe that part of the problem is that as students advance through coursework, opportunities to explore numbers in conceptually meaningful, rigorous ways are diminished. This article explores a possible remedy for such scenarios - namely, Number Talks. Number Talks can be used in the math classroom from kindergarten through twelfth grade to build strong procedural fluency built upon conceptual understanding and mental calculation in a manner that is engaging (and dare I say) fun for students of all ages.

2 What are Number Talks?

Number Talks are a brief (5 to 15 minutes), daily activity that focus on the development of mental math. Students do not use paper and pencil. In fact, many teachers implement Number Talks with students away from their desks, sitting on the carpet or floor. Students are provided with a mathematical prompt to think about, then use hand signals (such as thumbs up against the chest) to signal to the teacher they have a strategy to solve the problem. Hand signals let students discreetly communicate with the teacher without squelching the thinking of classmates. Once the students have had ample time to think, the teacher facilitates a whole-class discussion of mental strategies. For instance, a second grade teacher might ask her students to consider the task $24 + 26$. After a period of quiet thinking, the following conversation is typical.

TEACHER : (*After collecting values for the prompt from students*) Would someone like to defend one of these answers?

LISA : (*Raising her hand enthusiastically*) Ohh! Oh! Miss Jones!

TEACHER : Yes, Lisa?

LISA : I would like to defend 50. I found this using tens and ones.

TEACHER : Tell me about this Lisa.

LISA : Well, 24 has 2 tens and 26 has 2 tens so, I added the two 20s together and got 40. And I added the ones, the 4 and the 6 and got 10. (*Teacher is recording Lisa's work accurately to how she describes her strategy as she talks*).

TEACHER : Okay. Class do you see what she's done so far? (*Heads nod*).

LISA : And then I added the 40 and the 10 together and got 50.

TEACHER : That's terrific, Lisa. Can someone summarize Lisa's method for me?

3 NCTM Mathematics Teaching Practices

Principles to Actions: Ensuring Mathematical Success for All (NCTM, 2014) list eight mathematics teaching practices that encourage effective teaching and learning. One of these focuses on building procedural fluency from conceptual understanding. "Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems" (NCTM, 2014, p. 42). Through Number Talks, students are encouraged to make sense of the mathematics before them, use multiple representations to deepen their understanding of the mathematics, and make connections among different strategies in order to develop more efficient and flexible thinking. "Something wonderful happens when students learn they can make sense of mathematics in their own ways, make mathematically convincing arguments, and critique and build on the ideas of their peers" (Humphreys & Parker, 2015, p. 5).

4 The Role of the Teacher

The most integral component in Number Talks is the role of the teacher. "Teaching by telling is the method most of us experienced as students . . . our role must shift from being the sole authority in imparting information and confirming correct answers to assuming the interrelated roles of facilitator, questioner, listener, and learner" (Parrish, 2014, p. 12). The beauty of Number Talks is that through sharing their own strategies and connecting to the strategies of others, students assume control over their own learning without the teacher telling them how they should think. With Number Talks, students do the thinking themselves! Due to this shift in responsibility, teachers focus instead on their role as facilitator, managing conversations, recording thinking of students, and questioning when needed. Recording the students' thinking in a way that accurately reflects what they say out loud in a way that encourages connections among strategies becomes a focus of the teacher (see Figure 1 for an example of the recorded thinking of the 2nd grade Number Talk explored in our earlier scenario with Lisa and her teacher).

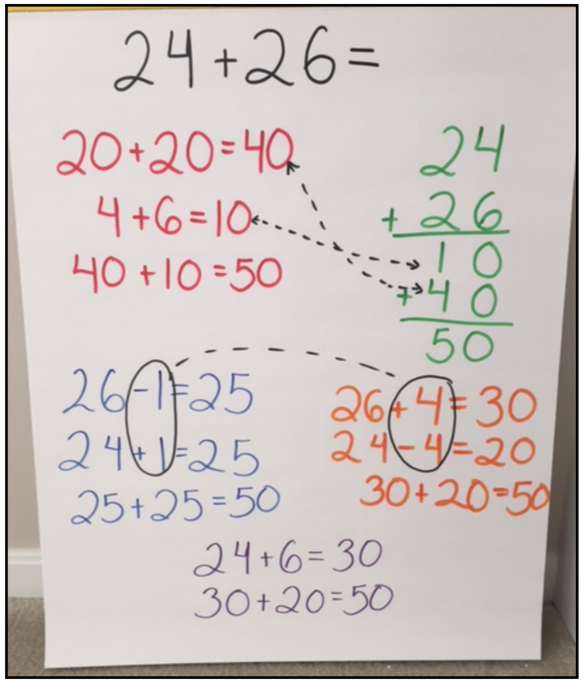

Fig. 1: *Teacher transcription of student thinking.*

5 Engaging Advanced Learners

During a presentation to a room full of middle and high school preservice teachers at a recent Miami University Council of Teachers of Mathematics meeting, I offered the following prompt as a Number Talk: $3\frac{1}{2}\left(7.25+\frac{15}{4}\right)$. Before reading further, take a moment and consider a strategy to mentally compute the value of the expression. After several minutes, the teacher candidates shared a variety of approaches for simplifying the expression. Figure 2 shows the recorded work for a person that began the problem by breaking apart the 7.25 to be able to make a whole. Another person used the closest whole numbers to $3\frac{1}{2}$ to find the final value of the expression. Such an approach is shown in Figure 3.

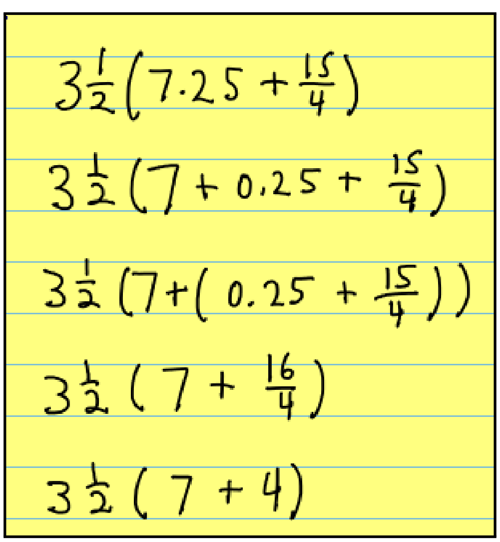

Fig. 2: *Strategy from Student A.*

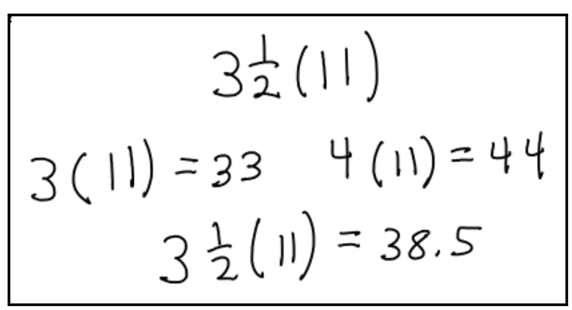

Fig. 3: *Strategy from Student B.*

Smiles and thoughts of "oh yeah, I get that" permeated the room. Candidates used estimation, decimals, common denominators, decomposing the 3 and the $\frac{1}{2}$, fractions greater than one and many more strategies. The task challenged even the most capable of students. A routine computational problem was transformed into a deep learning opportunity connecting alternative numerical representations with algebraic ideas.

A prompt as complex as the one presented to this group can be intimidating as a mental computation. As I examined the faces of the audience, I saw the look of defeat in the furrowed brows of some participants. In a situation where students may be hesitant to begin thinking, it can be helpful to use a Number String (Fosnot & Dolk, 2001), a series of Number Talk prompts used to chunk the prompt to focus on mathematical relationships into digestible chunks. Number Strings support hesitant thinkers by giving them a place to begin. Below, we provide a Number String that could be used for the prompt $3\frac{1}{2}\left(7.25+\frac{15}{4}\right)$.

Prompt 1: $7.25+\frac{15}{4}$

Prompt 2: $3\left(7.25+\frac{15}{4}\right)$

Prompt 3: $\frac{1}{2}\left(7.25+\frac{15}{4}\right)$

Prompt 4: $3\frac{1}{2}\left(7.25+\frac{15}{4}\right)$

6 Flexible Thinking by Students

In facilitating Number Talks, teachers see a variety of strategies and encourage students to defend their thinking. Once strategies are presented and recorded, students are provided with opportunities to make connections between strategies and adjust their own thinking. In Figure 4 we see student strategies from an elementary dot talk. Connections can be made between the strategies of Student 1 and Student 3 - one student sees the images as a duplicate image and then adds the extra dot, whereas the other students sees the images as a duplicate image and then subtracts the missing dot. Both students are building a foundation in the use of doubles for calculations. The prompt for

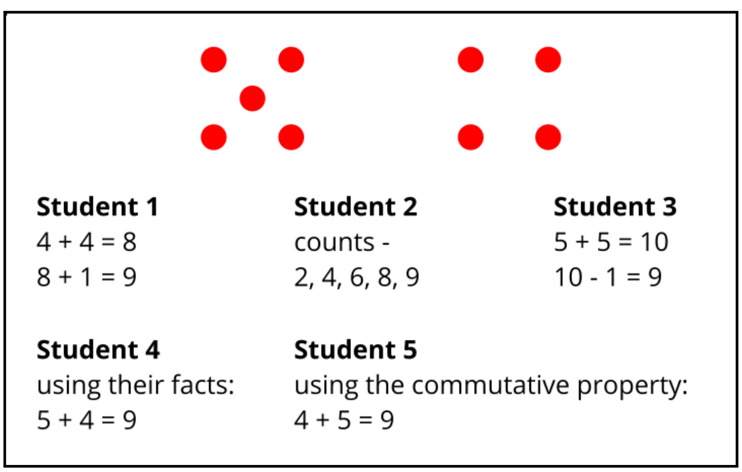

Fig. 4: *Elementary Number Talk prompt and resulting student strategies.*

Figure 5 asks students to decide if they think the resulting sum would be close to $\frac{1}{2}$, close to 1, or close to 2. This type of prompt resulted in several students using estimation, a skill that encourages student number sense.

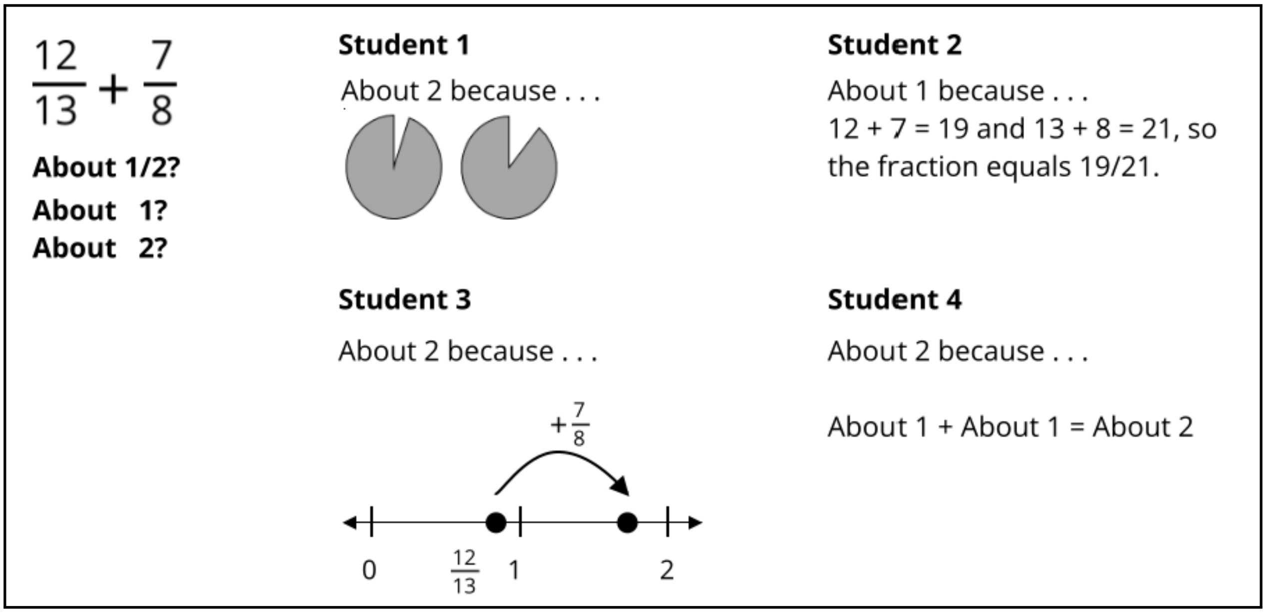

Fig. 5: *Number Talk prompt for intermediate students and resulting strategies.*

Figure 6 suggests how middle school students use flexible approaches to make sense of rational number subtraction. The first student begins with an incorrect explanation of his abstract thinking, but the next two students use concrete objects (counting chips) and model the task at a representational level to help Student 1 adjust his thinking.

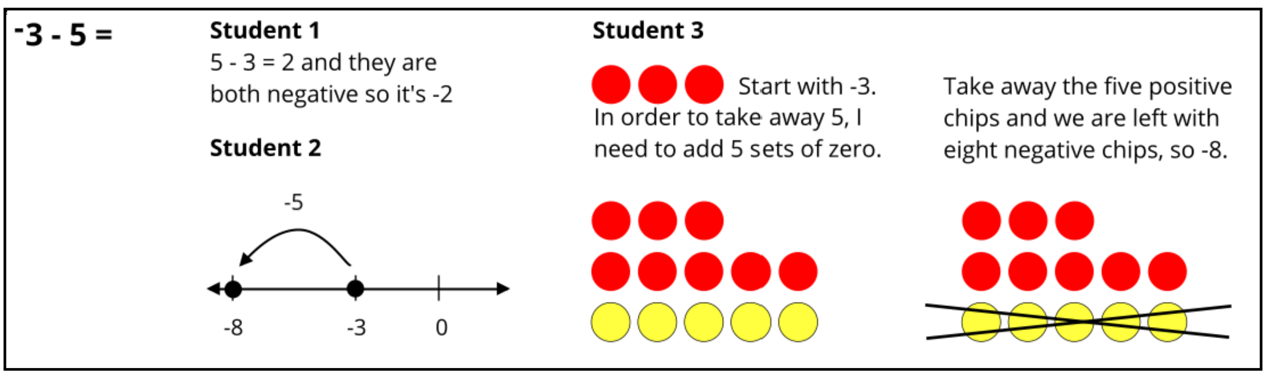

Fig. 6: *Number Talk prompt for middle level students and resulting strategies.*

The high school example in Figure 7 shows a common mistake students make when they incorrectly try to use FOIL for a trinomial multiplied by a binomial. It is important to let all strategies be heard and to help students adjust their thinking to correct mistakes.

$$\left(x^2-3x+5\right)\left(2x-1\right)$$

Student #1:

	x^2	$-3x$	5
$2x$	$2x^3$	$-6x^2$	$10x$
-1	$-x^2$	$3x$	-5

$$=2x^3-7x^2+13x-5$$

Student #2:

$$=2x^3-x^2+10x-5$$

Student #3:

$$=2x^3-x^2-6x^2+3x+10x-5$$
$$=2x^3-7x^2+13x-5$$

Fig. 7: *Number Talk prompt for High School students and resulting strategies.*

7 In Conclusion

Fluency has been defined as applying mathematics accurately, efficiently, and flexibly (CCSSI, 2009). As students engage in Number Talks, they explain the mathematics behind their thinking, using and connecting strategies flexibly while striving for efficiency. By providing students with the opportunity to engage in Number Talks, teachers facilitate discourse among students about their thinking, help students build connections among strategies, and present students with opportunities to put their knowledge into practice as they solve problems. Figure 8 provides a list of teacher and student actions that build procedural fluency from conceptual understanding provided in *Principles to Actions* (NCTM, 2014, p. 47) As mathematics instruction continues to transform and advance in the way that we build students' fluency and number sense, we aim to create thinkers. Number talks provide a great daily activity that can be incorporated into teachers' pre-existing lesson structures. With Number Talks, we help students develop self- confidence with numbers, to leave the calculator in their backpack more frequently and instead use their toolbox of mental strategies.

8 Exploring Further

There are many informative video examples available to learn more about Number Talks. Jo Boaler leads 6th grade students in a dot Number Talk at `https://www.youcubed.org/jo-dot-card-number-talk/`. The Teaching Channel (`https://www.teachingchannel.org`) has numerous video examples of teachers across the grades using Number Talks in their classrooms. Sherry Parrish also provides filmed Number Talks as a part of her Number Talks books.

What are *teachers* doing?	What are *students* doing?
Providing students with opportunities to use their own reasoning strategies and methods for solving problems.	Making sure that they understand and can explain the mathematical basis for the procedures that they are using.
Asking students to discuss and explain why the procedures that they are using work to solve particular problems.	Demonstrating flexible use of strategies and methods while reflecting on which procedures seem to work best for specific types of problems.
Connecting student-generated strategies and methods to more efficient procedures as appropriate.	Determining whether specific approaches generalize to a broad class of problems.
Using visual models to support students' understanding of general methods.	Striving to use procedures appropriately and efficiently.
Providing students with opportunities for distributed practice of procedures.	

Fig. 8: *Teacher and Student Actions for Building Procedural Fluency (NCTM, 2014, p. 47).*

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