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CONTACT: Kate Strauss
Community Relations
Buena Park School District
714-514-0523
kstrauss@bpsd.us

PART I: NEW APPROACH TO MATH BUILDS ON STUDENTS' OWN MATHEMATICAL THINKING TO ANSWER THE WHYs AND HOWs OF MATH

Cognitively Guided Instruction (CGI) leads students to discover math concepts and rules organically and lays the groundwork for future success

Buena Park, CA — Buena Park School District is implementing a student-centered approach to teaching math called Cognitively Guided Instruction, or CGI, that is turning traditional teaching methods upside down.

CGI is rooted in four decades of research showing that children bring to the classroom their own intuitive mathematical knowledge and their own way of processing the world around them. CGI lessons build on this prior knowledge. With CGI, students solve math problems in a way that makes sense to them, and then they talk about their methods and ideas with one another. This process builds meaningful connections among mathematical concepts and a stronger foundation that is based on a variety of strategies rather than one "correct" way to solve a problem. In the end, students have a clear sense of the "why" and "how" of math rather than just the "what."

On this particular day, students in Ms. Little's third grade class are learning to compare fractions by considering a topic that interests all of them: popcorn. "Four people sharing two bags of popcorn will each get MORE popcorn than six people sharing three bags of popcorn," she posits. "I want you to tell me if this statement is true." The students at the green table by the window have learned how to tackle a mathematical question. Taking out a blank piece of paper, Carlos, Michelle, Elsa, and Veronica pick up their pencils, pause for a moment or two, and then begin to draw.

Carlos and Michelle both draw rectangles to represent the popcorn and divide them into pieces to compare the sizes. Elsa draws circles to represent the people and draws arrows to her square popcorns to determine how they will be divided. Veronica writes "2 bags → 4 people" and "1 bag →2 people," and then makes a numerical chart. Three different types of thinking lead these students to the same conclusion that the statement is false. And without realizing it, they have used their own strategies to figure out some basic rules about fractions and the relationship between fractions and division. A simple story problem about popcorn becomes a window to a larger mathematical idea.

The next step is perhaps the most critical: The students must now explain their thinking to one another. Carlos, Michelle, Elsa, and Veronica break into pairs and take turns explaining their approach to one another, and in turn, they are asked to restate one another's explanations and ask if they have correctly understood that approach. Now, they are equipped with additional methods at their disposal for approaching this popcorn problem.

Circulating around the classroom, Ms. Little listens to these conversations and takes note of which student work samples that she would like to discuss as a class when they reconvene, samples that will move the lesson forward. She selects some because they model strategies that show an increasingly sophisticated understanding of the topic, and she selects others because they illuminate a common error. The samples are projected onto the white board and discussed together using a document camera. Ms. Little also comments on vocabulary that she overheard during these discussions: "I heard someone say 'equivalent,' and I heard a lot of you use the words 'numerator' and 'denominator.'"

Ms. Little is careful to save time each week for a class favorite called "Hands Down, Speak Out," when the students sit in a circle and debate a math-based topic. Last week, they were given a chart that listed recommended screen time hours for people at different ages and asked to interpret the data. The students had a spirited discussion about what the numbers revealed to them, what conclusions they drew, and how they felt about the data.

This inquiry-based approach to math activates a genuine curiosity and a sense of ownership, where students direct their own learning. The ability to explain their own thinking and strategies and discover mathematical rules and properties through inquiry and conversation elevates mathematics to a new level of understanding. And regardless of whether a student struggles or excels in math, they all learn from one another.

To become proficient at implementing the CGI method in the classroom, Buena Park School District teachers have spent 30 hours in training with Dr. Jody Guarino, the mathematics guru at the Orange County Department of Education. During one of these trainings, a first grade teacher is frustrated by the disconnect that she sees in her classroom with students who have memorized how to count by tens (10, 20, 30 , 40, 50….) but do not actually understand what "ten" means. "The rote method of teaching actually does our children a disservice in the long run," she says. These same students who can count by tens endlessly often have difficulty decomposing the number “eleven” into “ten” and “one,” or recognizing that twenty-one cars mean two groups of ten plus one more. With CGI, the concept of a “ten” group comes first, and children learn to count by tens naturally by working with the numbers.

At these workshops, teachers collaborate to figure out when to use certain types of math problems and how to group standards into coherent ideas. Today, they’re discussing fractions. At the first-grade level, students learn to divide circles and rectangles into equal shares and to describe those shares using the words “half” and “quarter.” At the second-grade level, students are still partitioning circles and rectangles, but they’re adding the word “third.” In time, students discover that the more equal shares you divide a shape into, the smaller the shares will be. With CGI, students learn this relationship organically rather than by memorizing rules without understanding the “why.” Second graders in the Buena Park School District, for example, are coming to understand that the number “4” on the bottom of “1/4” represents the number of people sharing.

The teachers in this workshop have fun relating fractions back to everyday life. Indeed, the philosophy of CGI is to make word problems accessible and relatable; teachers often include student names in the problems and drop in meaningful references. Consider sandwiches, for example – a staple for many children – in teaching the concept of “half.” Students discover that a sandwich can be cut in half horizontally, vertically, or diagonally, and the size of the half is still the same.

Teachers also recognize that introducing vocabulary and concepts before introducing symbols is critical to building a strong foundational understanding. Fractions are the biggest gatekeeper to success in algebra and STEM; the CGI groundwork laid in early elementary is essential for mathematical thinking later. Indeed, research shows that this approach works. In a three-year study, the problem-solving performance of CGI students rose substantially over that of non-CGI students, and the longer students participated in the program, the greater their gains. In addition, despite CGI’s decreased emphasis on rote learning, CGI students performed better on their number facts than did non-CGI students.

Back in Ms. Little’s third grade class, the students have moved onto another topic: the number of one-foot by one-foot tiles needed to cover a table measuring eleven feet by three feet. First, though, they must discuss with their tablemates the concept of “area” and exactly why the word “square” is an important part of the answer. For these students, holding a conversation about this abstract question is as easy as two plus two.

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