What is Cognitively Guided Instruction?

A CGI classroom is where you build on the math knowledge of your children according to what they know…You don't build objectives that say they should be doing this, this, this, and this. You sort of take what they know and build from there.
(Susan Gehn, First Grade Teacher)

Cognitively Guided Instruction (CGI) is captured in the above statement of an experienced CGI teacher; it is about teachers making instructional decisions based on their knowledge of individual children's thinking. CGI was created by Elizabeth Fennema, Thomas Carpenter, Penelope Peterson, and Megan Franke.

What CGI Is

CGI is not a traditional primary school mathematics program. Children in CGI classrooms spend most of their time solving problems, usually problems that are related to a book the teacher has to read to them, a unit they may be studying outside of mathematics class, or something going on in their lives. Various physical materials are available to children to assist them in solving the problems. Each child decides how and when to use the materials, fingers, paper and pencil; or to solve the problem mentally. Children are not shown how to solve the problems. Instead each child solves them in any way that they can, sometimes in more than one way, and reports how the problem was solved to peers and teacher. The teacher and peers listen and question until they understand the problem solutions, and then the entire process is repeated. Using information from each child's reporting of problem solutions, teachers make decisions about what each child knows and how instruction should be structured to enable that child to learn. Starting at the kindergarten level, CGI teachers ask children to solve a large variety of problems involving addition, subtraction, multiplication, or division. Children learn place value as they invent procedures to solve problems that require regrouping and counting by 10s. Problems are selected carefully so that children count by 1s, 10s, or 100s depending on the child; discuss relationships between basic number facts; and invent procedures to solve problems involving two-and three-digit numbers.

Above information taken from ***Children's Mathematics: Cognitively Guided Instruction***

Typical Problem Based Progression for Solving Problems:

- ☐ **Direct Modeling** – student acts out the situation using manipulatives or diagrams.

- ☐ **Counting Strategies** – student utilizes strategies such as counting up to solve the problem. They use aids such as number lines or hundreds charts to help keep track of their counting. Many students get "stuck" at this level, never really becoming automatic with their facts, instead relying on a variety of counting strategies or technology such as calculators or spreadsheets.

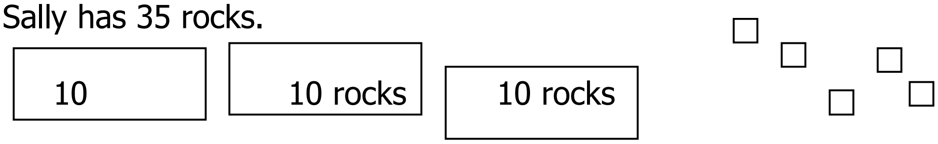
- ☐ **Number Facts** – student utilizes known number facts to solve problems.

One way to develop computational fluency is to have students frequently solve problems and then have the opportunity to evaluate if the answer makes sense. I would suggest posing problems based on the Cognitively Guided Instruction (CGI) problem types. The child solves the problem by any method that makes sense to them. Note the main focus at the K-2 level is addition and subtraction, but do not be afraid to use the multiplication and division situations on the second CGI problem type chart. It has been shown students as early as kindergarten can successfully work with division (even reporting their solutions using fractions) in a problem based situation such as fair sharing of cookies.

A problem and related solutions might look like this:

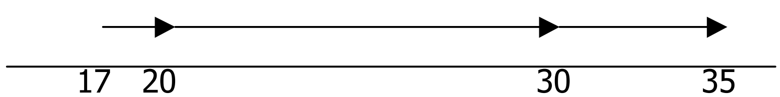
Sally has 35 rocks. John has 17 rocks. How many more rocks does Sally have than John?

Student draws a diagram or acts out solution using counters:
Sally has 35 rocks.



John has 17, so Sally has 18, 19, 20 (that's 3), 30 (that's 13), 31, 32, 33, 34, 35 (that's 18 more). Sally has 18 more rocks than John does.

Another diagram we have seen is an open number line.



+3 +10 +5 = + 18

Equation method: Either 17 + 18 = 35 or 35 – 17 = 18

This connection between addition and subtraction may not be obvious to the children. Discussion of the problem and how people show their thinking will help the child internalize the process.

The goal at this point is to ***understand*** the action of addition, subtraction, multiplication and division. We will be focusing on how to record that action using math notation only when students can do so with understanding. It is through daily discussions of problem solving that we hope to move students from direct modeling to counting strategies to using number facts to solve problems, but if we rush this process the students may be mimicking our instruction with no real understanding.

There are 4 Problem Types for Addition and Subtraction

Problem Types			
Join Problems	**(Result Unknown)** Sally has 4 rocks. John gave her 6 more rocks. How many rocks does Sally have altogether?	**(Change Unknown)** Sally had 4 rocks. How many rocks does she need to have 10 rocks altogether?	**(Start Unknown)** Sally had some rocks. John gave her 6 more rocks. Now she has 10 rocks. How many rocks did Sally have to start with?
Separate Problems	**(Result Unknown)** Sally had 10 rocks. She gave 4 to John. How many rocks does Sally have left?	**(Change Unknown)** Sally had 10 rocks. She gave some to John. Now she has 6 rocks left. How many rocks did Sally give to John?	**(Start Unknown)** Sally had some rocks. She gave 4 to John. Now she has 6 rocks left. How many rocks did Sally have to start with?
Part-Part-Whole Problems	**(Whole Unknown)** Sally has 4 red rocks and 6 blue rocks. How many rocks does she have?	**(Part Unknown)** Sally has 10 rocks. 4 are red and the rest are blue. How many blue rocks does Sally have?	
Compare Problems	**(Difference Unknown)** Sally has 10 rocks. John has 6 rocks. How man more rocks does Sally have than John?	**(Quantity Unknown)** John has 6 rocks. Sally has 4 more than John. How many rocks does Sally have?	**(Referent Unknown)** Sally has 10 rocks. She has 6 more rocks than John. How many rocks does John have?

Note - Many students will solve subtraction problems by thinking of the related addition fact. For example to solve the fact $10 - 4 = \square$ the student thinks $4 + \square = 10$. Piaget wrote that this is what always happens in our brain but that over time we can become so adept at it that it happens on an unconscious level. So even though these activities are listed as subtraction activities do not be surprised if the students figure out the answers using addition.

Problem Structures for Multiplication and Division

Problem Types	Multiplication	Partition Division	Measurement Division
Equal Group Problems	**(Whole unknown)** Mark has 4 bags of apples. There are 5 apples in each bag. How many apples does Mark have altogether?	**(Size of groups unknown)** Mark has 20 apples. He wants to share them equally among his 4 friends. How many apples will each friend receive?	**(Number of groups unknown)** Mark has 20 apples. He puts them in bags with 5 apples in each. How many bags did he use?
Equal Group Problems (rate)	**(Whole unknown)** If apples cost 4 cents each, how much would 5 apples cost?	**(Size of groups unknown)** Jill paid 20 cents for 5 apples. What is the cost of 1 apple?	**(Number of groups unknown)** Jill bought apples for 4 cents each. She spent 20 cents. How many apples did she buy?
Equal Group Problems (rate)	**(Whole unknown)** Peter walked for 5 hours at 4 miles per hour. How far did he walk?	**(Size of groups unknown)** Peter walked 20 miles in 5 hours. How fast was he walking (in miles per hour)?	**(Number of groups unknown)** Peter walked 20 miles at a rate of 4 miles per hour. How long did he walk for?
Compare Problems	**(Product unknown)** Jill picked 4 apples. Bill picked 5 times as many. How many apples did Bill pick?	**(Set size unknown)** Mark picked 20 apples. He picked 4 times as many as Jill. How many apples did Jill pick?	**(Multiplier Unknown)** Mark Picked 20 apples and Jill picked only 4. How many times as many apples did Mark pick as Jill did?
Compare Problems	**(Product unknown)** This month Mark saved 5 times as much money as last month. Last month he saved $4. How much did he save this month?	**(Set size unknown)** This month Mark saved 5 times as much as he did last month. If he saved $20 last month, how much did he save last month?	**(Multiplier Unknown)** This month Mark saved $20. Last month he saved $4. How many times as much money did he save this month as last?

Problems taken from Van de Walle and Lovin page 78 and 79