Assessing Mathematical Learning: Observing and Listening to Children

by Juanita V. Copley

"Donnie, come show Miss Nita how good you are at numbers!" Donnie's parents smiled broadly in expectation as their four-year-old son took a deep breath and began an addition recitation in a sing-song voice, "One plus one is two. Two plus two is four. Three plus three is six. Four plus four is eight . . . . " Young Donnie continued the addition fact recitation with very little error until he ended triumphantly with "Ten plus ten is funny!" The listening adults all laughed appreciatively; however, their perceptions of Donnie's mathematical learning were very different. Donnie's parents had taught their son to recite *the basic facts* after listening and memorizing a song. Miss Nita, on the other hand, wondered how much Donnie understood about the words he had memorized and later, while *playing store,* discovered that his concept of numbers was quite incomplete.

The assessment of young children's mathematical learning has become increasingly more important over the past few years. Because of a consensus from researchers and practitioners that early childhood is a critical period for school readiness, early childhood educators believe that mathematics learning is essential. When those beliefs are combined with the new accountability standards for national programs, the testing of young children in early mathematics learning often becomes a frequent occurrence. The lack of reliable, valid tests to assess children's mathematical understanding along with the variability of young children's knowledge is a widely debated topic and not the focus of this article. Rather, the purpose of this article is to discuss another, more important purpose of assessment, i.e. to support the mathematical learning of the young child.

The recently published joint position statement by the National Council of Teachers of Mathematics and the National Association for the Education of the Young Child supports this idea. They concluded their list of ten recommendations for classroom practices with one directly relating to assessment. "In high-quality mathematics education for three- to six-year-old children, teachers and other key professionals should *support children's learning* by *thoughtfully* and *continually assessing all children's mathematical knowledge, skills, and strategies.*" Compatible with the definition of authentic assessment, this recommendation clearly defines the role of the assessor as he tries to understand what a child knows, how he learns, and what to teach next. Detailed observations, probing questions, frequent listening opportunities, and a variety of documentation should all be parts of the teacher's assessment repertoire.

Observing with Purpose

When asked how they assess, most early childhood educators respond, "by observing." Observing with purpose requires that the assessor first be familiar with the concepts that are the focus of early mathematical learning. Mathematics is more than numbers; it also involves geometric concepts, pattern recognition and generation, measurement processes, and analysis of data. Secondly, it is critical that the assessor have an open mind as she observes the young child. Contrary to long-established developmental continuums, young children often demonstrate rather amazing mathematical learning. While their understanding may be incomplete, their potential for learning mathematics can be quite exciting.

So, what and when do you observe? Children potentially do mathematics everywhere! Children constructing in the block

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center model their understanding of the attributes of geometric shapes. Children gathering enough materials for an art project demonstrate their concept of number and one-to-one correspondence. Children acting out a restaurant scenario and calculating the bill represent numerals and their understanding of numbers and operations. Children deciding on a fair way to share materials during outside play demonstrate their ability to divide numbers or time into equal groups or intervals. Children participating in the daily class routines, counting the number of students in the group, or the number of days until a big event are modeling their counting strategies. Children deciding which of the class pumpkins are the biggest and expressing dismay when the heaviest ones don't sink are using measuring concepts for their experiments. All of these examples are common occurrences in early childhood settings and, for the focused observer, provide an opportunity for the assessment of mathematical learning. These assessments provide information to the teacher and potentially suggest future experiences and investigations.

Asking Thoughtful Questions and Listening to Children

Both parents and teachers question young children continually. Unfortunately, most of their questions involve particular behaviors ("Where is your coat?" "What do you do when you sneeze?" "Did you say, 'Thank you?'" "How can you say you are sorry?"), testing for particular knowledge ("How many pieces of candy do you have?" "What is this shape?" "How many stickers do you have now?" "How high can you count?"), or reminders of previously-learned information ("What did I tell you to remember about numbers?" "How many sides does a triangle have?" "Remember what happens when I add two more?"). While these samples are indeed questions, the most informative questions for assessment purposes are often the more probing, thoughtful ones. Some general questions that often provide interesting insights into a child's thinking are:

- What happened? How do you know?
- What would happen if . . . ?
- I wonder why . . . ? I wonder what would work?
- What else can you find that is like this?
- What if . . . ?
- Maybe it's because . . . .
- Is there any other way to show . . . ? Can you show me another way to . . . ?
- About how many . . . ? Why do you think so?
- How many more . . . ? How do you know?
- Silly Sam thinks that . . . ? What do you think? Where is he wrong? Why do you think he is silly?
- How are these alike? How are they different?
- Is this a _____?
- Why isn't this a _____?

Some of the most interesting assessments occur as the teacher listens to the responses of young children to questions that probe children's initial responses. For example, when prekindergarten children measured themselves next to a large paper bear totem pole, many of them found that they measured 4 or 5 bears tall. The next day, when they measured themselves next to a totem pole made out of small paper bears, they found that their measurement had increased to 6 or 7 bears tall. When asked why the numbers got bigger, most children confidently responded with "I growed!" or "My brother stretched me" or "I ate lots of food last night" or some similar response. Other children expressed puzzlement at the situation and stated that it was "strange" or "funny." A few responded in amazement that the "bears were different" and that is "just how it is."

All of these responses inform the teacher's instruction and provide suggestions for how the teacher can best support a young child's learning. For the children who gave the "I just growed" responses, many other activities with different-sized length measurers could be encouraged. For the children who were puzzled or amazed at the teacher's inquiry, questions that require children to explain their reasoning should be asked. Then, experiences with other measurement tools could be initiated. ("How many small (big) bears could you hold in your hand?" or "How many big (small) cups of sand could the bucket hold?")

Counting situations often provide opportunities for probing questions. When asked why the six-legged puppet had one extra leg for a hand, one child reasoned that "maybe the person who made the puppet had six fingers." After everyone in the class had counted their fingers to find out how many they had, one child responded, "If I count my fingers real fast, I get six!" Indeed, these children expressed two different understandings of conservation of numbers. In another example, a child who said he couldn't count past 20 was able to correctly count to 100 when the decade numbers were stated by the teacher.

Teacher: Twenty, twenty-one . . .
Child: Twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, twenty-eight, twenty-nine . . . (pause)
Teacher: Thirty, thirty-one . . .
Child: Thirty-two, thirty-three, thirty-four, thirty-five, thirty-six, thirty-seven, thirty-eight, thirty-nine . . . (pause)

They continued counting until the number 100 was reached. Obviously, the child recognized the number pattern of the single digits and had begun to develop an understanding of our decimal system.

Documenting Children's Work

Collecting samples of children's work and documenting the results is perhaps one of the most beneficial efforts towards understanding a child's mathematical learning over time. One of the reasons that multiple, continual assessments are recommended for young children is the variability of young children's knowledge and skills. Often, the variability occurs within one day, one hour, or even from minute to minute. A collection of children's work along with their verbal comments about their work is quite helpful and necessary to understanding children and the support they need to facilitate their learning.

Gaby's picture of the counting circle and her verbal explanation informed the teacher that she understood pattern and had actually begun to generate and extend the +2 pattern on her own.

Ryan's representation of the story, *Mrs. Ryan and Her Houseful of Cats* and her words, "One cat on the roof and seven cats inside . . . eight cats!" indicated that she understood eight as made up of two parts, seven and one.

The rectangular quilt made by a prekindergarten class and the many conversations that took place about the shapes and patterns they identified in the quilt over a period of several weeks demonstrated that children listened to others and began to increasingly identify colors, shapes, and sizes.

PHOTOGRAPHS PROVIDED BY THE AUTHOR

The drawing of the blue creature with the "million" legs that was discovered during the archeological dig in the sand table indicated that Jeffery could identify color and size attributes of an object but had difficult counting and representing the specific number of legs. All of these are just samples of documentation. Analyzed separately, each of them give a small piece of information about the child's mathematical understanding. Analyzed together, with a child's other documentation samples collected over time, a teacher can assess a child's understanding and learn how best to support further learning.

The Importance of Language

To support the learning of young children and assess children's learning accurately, teachers must be aware that language often carries different meanings to young children. Part of the assessor's responsibility is to question the child, express the idea in different ways, and continue to make more observations to clarify the child's understanding. To relate the

importance of language, a few examples of miscommunication between an assessor and a young child are described:

■ Children were asked to report the results of a yarn toss game. Although the teacher constantly asked children to give the responses that were *different*, the children continually repeated the same answers over and over again. She expected them to report the ones that had *different* numerical responses; they thought a toss was *different* because it was their specific result and they each used *different* colors of yarn.

■ An assessor asked individual children to identify triangles from a series of shapes. Most children could identify the more typically shaped triangles with little problem and also give a definition of a triangle as "a shape with three sides." During her assessment, however, one of the triangles fell off the table; and when she asked the child to identify it, she held it up so it was *standing on the point.* When she asked the child to identify the shape, the child replied that he didn't know, but he was sure it wasn't a triangle because it "didn't look like it." He was then asked to tell what a triangle was; and when he responded "a shape with three sides," she asked him again why the shape wasn't a triangle. Again, the child responded that it "didn't look like it" and that, in fact, it "needed to look like a girl" if it was going to be a triangle. Puzzled, the assessor asked where the child had seen triangles "that looked like girls." The child pointed to the restroom door down the hall. After a quick glance at the doors, the teacher understood the child's answer! The girl's bathroom had a circle with a triangle under it for girl and the boy's bathroom had a circle with a rectangle under it for boy.

■ The concept of *big* is one that children typically understand in relation to measurement ideas. When a teacher overheard a child explain that a physically large person was *little* and a smaller person was *big*, she decided to investigate this misunderstanding. She asked the child to tell why the one was *little* and the other was *big*. The child quickly responded, "Cause the *big* one has *more numbers"* (i.e. older) and the *little* one "*doesn't have as many."* Indeed, the child was correct — the *big* one was older and the *little* one was a beginning, much younger teacher!

In summary, the thoughtful, continual assessment of mathematical understanding is critical if the teacher is to support the young child's learning. The type of assessment that involves focused observations, thought-provoking questions, and documentation of children's work informs teacher and parents as they continue to learn about teaching and learning. John Cotton Dana once said, "Who dares to teach must never cease to learn." Perhaps a better paraphrase would be, "Who dares to assess, discovers how to teach, and never ceases to learn."

Using Beginnings Workshop to Train Teachers by Kay Albrecht

Finding the time to observe: Copley's ideas about observing may create anxiety in teachers' minds as they try to balance the myriad demands of the educational day. At a staff meeting, ask teachers to share the ways they manage to find observation time. Then, brainstorm additional ways that teachers might be able to find time to observe. Encourage teachers to use their creativity to open up the possibilities. When you have a good list, ask each teacher to pick one or two strategies to try. At the following staff meeting, share what worked and what didn't and then identify what to do to try again.

Scavenger hunt: Conduct a scavenger hunt around the classroom to find artifacts and children's work that could be used to assess mathematical learning. Divide teachers into small groups to look at and analyze the mathematical information provided.

What and where?: The point is made that children use mathematical skills throughout the classroom. Make a list of learning areas or centers and ask teachers to list the types of mathematical experiences children might have in each center. Don't stop until you have considered how to observe for mathematical learning everywhere.

More, more, more!: Copley says that children who need to learn a particular mathematical idea (like why different kinds of measurement instruments yield different results), the way to facilitate learning is to provide many varied and interesting experiences with the mathematical idea (in this case, measurement) during play. Work with teachers to explore this idea and to consider the many ways measurement (or any other mathematical skill) could be presented to children to incorporate into their play.