TEACHING PRESCHOOLERS ABOUT LIQUID VOLUME

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Measurement helps us determine the size of something. Volume is one of three important areas of measurement, along with length and area (National Research Council, 2009). Volume describes the size of a space. To measure something, the measurer must decide on the unit of measurement. The volume of a space is the quantity of the units of measurement it takes to fill the space. Preschoolers typically measure liquid volume using direct comparison (e.g., "this one holds more") or by using non-standard units, such as plastic bottles or toy pitchers). Volume can be measured by "filling" a container with a fluid unit that takes the shape of the container until the container appears full. This guide provides an overview of young children's competencies at measuring volume, the developmental continuum for learning about volume, and teaching strategies that can help young children learn about volume.

Young Children's Competencies at Measuring Volume

Preschoolers love filling containers and pouring liquids from one container to another. Piaget theorized that preoperational learners (i.e., preschoolers) are not capable of conserving liquids. For example, imagine that a tall cylinder and a short, wide cylinder will both hold a liter of water. If both containers are filled with water, a preschooler will predict that the tall cylinder holds more. This is true even if the child sees that when the liquid is poured from the tall cylinder into the shorter cylinder, the short cylinder also is filled with liquid. Interactions with adults or more competent peers about important attributes of measuring liquid volume may also be helpful. Vygotsky theorized that having an adult or more competent peer who talks with and scaffolds for a child can help the child develop intellectual concepts and skills to help him measure.

For the most part, children are not able to conserve liquids until they transition into the stage of concrete operations, around age 5-7. Therefore, it is not until then that children are able to measure volume accurately using a particular unit of measurement (e.g., cups,

quarts, liters). They may not truly understand that the unit is a part of a whole until third gade (Reece & Kamii, 2001). They may, however, see the relative fullness of a container as a linear measurement problem; they watch to see how high the waterline is from the bottom of the container (Clements & Sarama, 2014). Preschoolers begin to use their understanding of cardinality to count how many units of liquid will fit into the space inside a container. Gradually, they learn that they need fewer units to fill a given space when the unit they use is larger.

Experts in the field of early mathematics have described developmental pathways or trajectories for children's growing understanding of volume (Clements & Sarama, 2014). This developmental view of awareness and understanding of liquid volume is summarized in Table 1.

Table 1. Steps/Ages in Learning to Think About Volume*

Steps/Ages	Skill	Related Competencies
STEP 1: Two & Three Year Olds	1.1 Thinking visually/holistically	Identifies capacity or volume as an attribute.
STEP 2: Four & Five Year Olds	2.1 Thinking visually/holistically	Compares two containers. Fills a container using another (smaller) container and counts the number of smaller containiners needed to fill the larger container. Compares how full one container is in relation to another.
STEP 3: Six Year Olds	3.1 Thinking visually/holistically	Recognizes the amount of a container that is full and the amount that is left to fill.
	3.2 Thinking about parts	Recognizes when a container is half full.
	3.3 Relating parts and wholes	Is able to estimate the number of cups it will take to fill a container.
STEP 4: Seven Year Olds		Counting.

**Adapted from Clements & Sarama (2014); Cross, Woods, & Schweingruber (2009).*

Strategies for Helping Young Children Learn About Volume

Engaging young children in the following five mathematical processes helps them develop and communicate their thinking about all areas of mathematics, including measuring liquid volume (National Council of Teachers of Mathematics, 2000). These mathematical processes are: (a) representing, (b) problem solving, (c) reasoning, (d) connecting, and (e) communicating. Educators can teach children to use these five processes to *mathematize* or relate shape concepts to their everyday world. Tables 2 and 3 provide examples of language and materials that teachers can employ to help children use these processes.

Representing. Children may represent their understanding of volume in a variety of ways. For example, children might represent the amount of liquid in a container by drawing the container and coloring in the portion that is full. They may represent the effect of the difference in the size of the units used to fill a container by drawing them (e.g., 4 small cups versus 6 larger cups).

Problem solving. "Problem solving and reasoning are the heart of mathematics" (NAEYC, 2010). Young children solve volume problems when they estimate how many of a particular unit of measure it will take to fill a container. Preschoolers solve the problem of which container holds more by visually examining and comparing the height of the liquid in the two containers. Six- and seven-year-olds can count the number of cups it takes to fill each container and compare the quantities.

Reasoning and proof. Teachers can challenge preschool children's reasoning by conversing with them about their work with liquid volume and asking them to ex-

plain the decisions they make as they work with it (e.g., "How do you know this one holds more liquid?" "What makes you think this container holds 10 cups of liquid?" "How can we check to see if you are correct?"

Connecting. At the preschool level teachers can help children to see the relationship of volume to their everyday world. Teachers can assist children in making explicit connections between earlier levels of understanding and more advanced concepts (a tall cylinder and a short wide cylinder can hold the same amount of liquid). They can help children link their thinking about volume to other areas of math, such as number sense (e.g., "How will we know how many cups this container holds? I know, let's count the cups!").

Communicating. Encouraging children to communicate their thinking about volume by verbalizing, drawing, writing, gesturing, and using concrete objects or symbols can help them share their ideas with other children and adults. As children learn that volume can be measured, they are better able to communicate about it. Helping children expand and use a rich vocabulary related to volume also supports their ability to communicate their thinking with others (e.g., a cup, a scoop full). Modeling and encouraging children to use informal and formal math terms to describe their thinking about volume in their everyday world will help to "mathematize" their world.

Strategies for Supporting Dual Language Learners

Teachers can support young DLLs in thinking about liquid volume by helping them use words in their home language and in English to label their perceptions of volume (e.g., empty/vacio, full/maximo, more/más). This process is most effective when the home and English language labels are used as the young DLL plays with emptying and filling containers with fluid materials (e.g., water, sand). Picture displays of containers in various states of fullness can be labeled in the young DLL's home language and English. These visual displays help the teacher, peers, and family members by reminding them of words to use when describing volume. Hand gestures and labels also can be used together to indicate various levels of fullness (e.g., "I looked in the wading pool, and there was only this much water. It was almost empty!"). While it may be difficult to find books about liquid volume in both English and another language (e.g., Spanish), teachers can create their own books using digital images and incorporating the young DLL's home language and English. Additionally, songs with actions can be developed that piggyback on familiar tunes (e.g., XXX GIVE AN EXAMPLE?). For further information, see the microteach guide, *Supporting Mathematical Learning of Young Dual Language Learners* (Beneke, 2016).

Table 2. Examples of teacher language that supports children's mathematical processes* with volume

Representing
How would it look if it was _____ (e.g., empty, full, half full)?
What could we use to show how full it is?
Let's take turns guessing how many cups it holds!
Can you make a picture that shows how full each container is?
How can we show the volume?
Problem-Solving
I wonder how we can find out how much is in this container?
How can we tell which one has more?
What would happen if we poured the liquid into this container?
I wonder how we could find how many cups of water this container will hold?
Reasoning & Proof
Why do you think the amount in this container is _____ (more, less) than the other one?
What makes you think that these two containers will hold the same amount of liquid?
How can we prove that this container holds more?
How can I check to see if this one has more?
Why did you use this cup to fill the container?
How can we show that the amount of liquid in the containers is _____ (different, the same).
Connecting
You know how to count. What if we count how many cups of liquid it takes to fill the container?
Do your mom or dad measure liquids at home? When? Why?
Who measures liquids in their job? Why?
Do you have bottles of liquid in your house? Which one holds the most? Which one holds the least?
Communicating
How is the volume in these bottles different?
Look at this one. It's really _____ (e.g., full, empty)!
Let's count out loud while we pour the cups of liquid into the container.

**Mathematical processes described by the National Research Council (2009).*

Table 3. Examples of useful materials for teaching and learning about liquid measurement in preschool

Water Table or Tubs
Liquid measuring cups
Transparent containers in varying height and diameter
Small Pitchers
Measuring Spoons
Books
How Do you Measure Liquids? By Thomas A and Heather Adamson
Capacity by Henry Pluckrose
A Fish Out of Water by Helen Palmer

Instructions for Doing the Microteach

1. This microteach is to take place with a group of at least 3 children, ideally of diverse abilities.

2. Assess the children in advance to determine what step they are on, on the pathway for liquid volume (see Table 1).

3. Select one mathematical process you will emphasize in your lesson (i.e., communicating, connecting, reasoning and proof, problem-solving, or representing).

4. Use the *Lesson Plan Template* to plan a lesson on liquid volume that will support the learning of the children you will be teaching. Consider how you will individualize for the children in your small group.

5. Videotape yourself implementing the lesson with the children.

6. Follow the *Procedure for Microteach* handout.

References

Clements, D. H., & Sarama, J. (2014). *Learning and teaching early math: The learning trajectory approach, 2nd ed*. New York, NY: Routledge.

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