

Building numeracy: Understanding numbers and how they work

Early care and education teachers know the importance of literacy—recognizing and understanding printed words. *Numeracy* is to numbers and math what literacy is to reading—the skill that lets us understand numbers and how they work together to let us solve everyday problems. From reading a temperature thermometer to completing a crossword puzzle to knowing that page 333 follows page 332 in a book, we rely on numeracy skills even when we’re not balancing an account or counting change.

Math educators acknowledge that most American adults are uncomfortable with their understanding of math functions and practice—for example, which is more— $\frac{1}{3}$ cup or $\frac{3}{8}$ cup? We generally avoid computations; we laugh nervously when asked to estimate distances, figure the appropriate amount to tip wait-staff after a restaurant meal, and determine cook time for a 12 $\frac{1}{2}$ -pound turkey that has to cook for 15 minutes per pound.

Unfortunately, our common math anxiety makes it difficult to communicate any excitement about numbers with young children.

The National Council of Teachers of Mathematics (NCTM) has developed a series of standards designed to bring number concepts

to early childhood classrooms. The standards focus on understanding, reasoning, and hands-on experiences and not on memorization, rote counting, or computation tricks. The standards reinforce numeracy as basic and cumulative—starting when you play “This little piggy ...” with an infant.

NCTM encourages teachers to focus on 5 specific areas of numeracy—problem solving, communication, reasoning,

connections, and estimation—and to incorporate each into all areas of the curriculum. Numeracy builds on the systems and experiences of discovery, observation, experimentation, and analysis common to all domains of development.

In *Beyond Facts and Flashcards* (1996), Jan Mokros recommends numeracy-building principles for both teachers and families. Most are familiar to early childhood

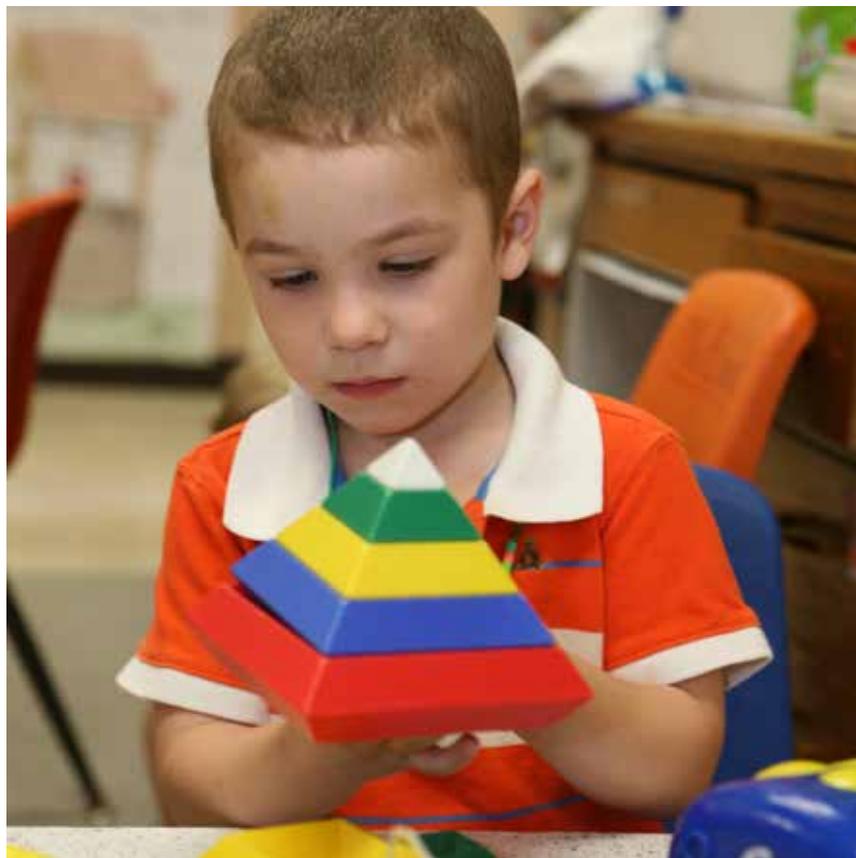


PHOTO BY SUSAN GAETZ

teachers because they are the same as basic literacy principles:

- Do math with children every day.
- Let children see and hear you do math.
- Explore math in the environment.
- Respond to children's questions and interests.
- Value mistakes while building understanding.

Include math discussions in routine activities like water play, block play, cooking and meal service, and preparing for partner games. Set up a math center for specific activities but help children build number sense in all areas of the curriculum.

Recognize and respond when children use math skills in routine interactions—with puzzles and the number of pieces that make it too easy or too challenging, with finger representations of age, and with correspondences like one-*napkin-per-place-setting* for snack. Be attentive to all of the ways in which numeracy impacts a child's interactions with people and the environment.

Active learning environments, with hands-on activities, foster curiosity, confidence, persistence, and understanding. Appropriate math education stimulates children to recognize and comprehend mathematical relationships in day-to-day situations—for example, the swing is closer than the back fence, 2 spoons of peas are more than 1, or Jessica is taller than Jill.

Math activities permeate the environment and offer numerous daily opportunities to chronicle children's developing numeracy skills: James compares the sizes and shapes of two wooden blocks,

Jenna and Will set the table for 2 restaurant customers, Chloe creates patterns using rubber stamps, and José organizes the dress-up area pairing shoes and boots.

These and similar activities rely on materials that are already in classroom use. Other numeracy materials are easy and inexpensive to obtain or build.

The activities in this article are most appropriate for children 3 years of age and older. The activities within each topic follow a general pattern of skill development and understanding but can stand alone, reinforcing skills and generating curiosity.

Ordering

Help children learn ordering through everyday conversations—*big, bigger, biggest*, for example—and by exploring one-to-one relationships—a *big* serving of peas has more than a *small* serving. These examples help children understand that numbers have order: one number can be greater than, less than, or the same as another.

Show me

Here's what you need:

- large familiar space
- teacher notes with prompts

1. Build on children's understanding of order with a movement game. To make the game easier (and quick flowing), make a list of prompts that are suitable to your environment—indoors or out. These might include the following:

- Run to something *larger* than this spoon.
- Pretend to pick up something that is *heavier* than a car.

- Pretend to carry something *lighter* than a paper towel.
- Hop onto something that is *tiny*.
- Hide behind something that is *taller* than you.
- Arrange three *small* buttons in a row.
- Pretend to squeeze a *huge* beach ball.
- Pick up something that is *smaller* than you.
- Point to something that is *bigger* than a bus.
- Stand next to something that is the *same* height as you.
- Touch something *big* and *small* at the same time.

2. Gather a small group of children and actively engage in the challenges.

Line up the tubes

Here's what you need:

- cardboard cylinders
- utility knife
- ruler
- marker
- spray paint
- presentation and storage container

1. Prepare this learning activity away from children. Measure, mark, and cut the cylinders into graduated sizes from 2 inches to 12 inches. Spray with paint and let dry thoroughly.
2. Introduce the cylinders and talk with children about the sizes.
3. Let children experiment with the tubes. Let them discover the two ways in which the cylinders can be ordered—shortest to longest or longest to shortest.
4. Challenge children to think about order. Ask "Can you place the cylinders in order with your eyes closed?" "Can

you put two cylinders together so that they are the same length as another single cylinder?"

Magnet lengths

Here's what you need:

- 2 rolls of magnetic tape, each about 60-inches long and ½-inch wide
- ½-inch wide plastic tape in 2 colors
- metal cookie sheets
- scissors
- presentation and storage container

1. Prepare this learning activity away from children. Peel the protective paper from one roll of magnetic tape. Measure and apply the colored tape on the adhesive side. Repeat with the second roll, applying the second color of plastic tape.

2. Cut each color of tape in lengths from 1 inch to 10 inches, in 1-inch increments. You will have 2 colored pieces of each length—1 inch, 2 inches, 3 inches and so forth.

3. Introduce the magnetic strips with a cookie sheet. Invite the children to experiment with the different arrangements of strips.

4. Help children notice that they can build a pyramid with each color, ordering the strips from longest to shortest.

5. Talk about how the pieces combine to make strips of equal length.

Classifying

Classifying and sorting activities allow children to group objects according to their *attributes*—similarities in size, shape, color, weight, or type, for example.

Dress-up clothes sort

Here's what you need:

- large open floor space
- dress-up clothes, including hats and shoes
- chart paper and marker

1. Gather the children in a big circle and introduce the clothes sort. Talk about how this sorting happens at home—clothes are sorted by size or in order to match socks, for example.

2. Put all the dress-up clothes in a pile and ask for suggestions on how to sort them. Challenge the children to think beyond the obvious shoes, hats, and jackets. Examine pieces of clothing

together and point out construction features like Velcro fasteners, ruffles, belt loops, buttons, or insignia badges for example.

3. Separate the clothing by two attributes first—clothing for the upper body and clothing for the lower body, for instance. As the children become proficient in identifying attributes, add qualifiers like color or function.

4. Chart children's responses, tally the numbers, and report to the children: For example, "We seem to have 3 blue hats, 4 coats with buttons, 8 pieces of clothing with Velcro fasteners, and no clothing pieces with ruffles."

What can you see?

Here's what you need:

- assorted loose parts including those made with paper, fabric, cellophane, plastic, wood, foil, and metal
- flashlight
- table or floor space for sorting and classifying
- presentation and storage container

PHOTO BY SUSAN GAETZ



- 2 labels reading *translucent* and *not translucent*

1. To prepare the activity, gather the loose parts. Place the labels on the floor. Show the flashlight and how some materials let light shine through (translucent) and some don't (not translucent or *opaque*).
2. Let the children take turns shining the light through an object and placing the object next to the correct label. Note that the objects will have differing degrees of translucency—some may allow only a bit of light to shine through, others a lot. Help the children negotiate, if necessary, in which category the object belongs.

Variation: Older children may want to add a third attribute: *transparent*. Transparent objects

allow light to flow through so thoroughly you could read text through it—glass, cling wrap, and plexiglass, for example.

Pom-pom sort

Here's what you need:

- 25 1-inch diameter pom-poms, 5 in each of five colors
- 25 round magnets or pieces of magnet tape
- cookie sheet
- presentation and storage container
- white glue

1. Prepare the activity by gluing the pom-poms to the magnet pieces. You will have five pom-poms in each of five colors.
2. Introduce the activity by discussing attributes. Let the children line up the pom-poms by color and then count each

color. Explore any differences in horizontal and vertical rows (there are none—5 is 5).

3. Ask for suggestions on how to sort by an attribute other than color.
4. Help the children see that they can sort by numbers—1 red, 2 yellow, 3 blue, 4 black, and 5 green, for example.
5. Challenge the children to investigate patterns—red, blue, blue, black, green, red—and copying the pattern.

Multiple attributes

Here's what you need:

- white paper
- copy machine
- templates of three basic shapes: square, circle, and triangle, for example
- scissors
- marker
- cardstock in 3 colors
- clear, adhesive-backed vinyl or laminator
- presentation and storage container
- 3 18-inch lengths of string
- table or floor space for sorting

1. Prepare the activity by tracing the shape templates onto white paper. Make three columns, one of 3 triangles, one of 3 circles, and one of 3 squares. Copy this shape master onto cardstock in 3 colors, giving you 3 copies of each shape in each of 3 colors. Laminate the colored sheets and cut out the shapes.
2. Introduce the activity by examining the shapes and colors with children.
3. Tie a knot at the ends of each length of string making 3 circles on the floor, each about 5-inches apart.

PHOTO BY SUSAN GAETZ



4. Encourage children to determine how they might sort the shapes and designate one circle for each attribute.
5. Rework the system with a different attribute.
6. Increase the challenge by overlapping two of the circles to encourage children to sort by color and shape at the same time.

Variation: Continue to explore attributes with common classroom loose parts. Encourage children to set their own sorting criteria including, for example, color, shape, size, pattern, noise-makers, or things that can bend.

Making patterns

Pattern exercises help children see sequences and relationships—skills required to recognize odd and even numbers and skip

counting (counting by 2s, for example). Discarded wallpaper books offer free and bountiful patterns for exploration. At a bit more cost, explore scrap booking paper and stickers at a local craft store.

Where's the pattern?

Here's what you need:

- multiples of 2 common loose parts like beads, buttons, pegs, or small counting animals
- tabletop or work tray for the floor
- presentation and storage container

1. Work in a small group or one-on-one. Divide the objects into two groups with one of each object in each group.
2. Set up a random pattern with several objects from one group. For example, a red bead, a

yellow button, a chip, a twig, and a green pom-pom.

3. Challenge the child to match your pattern using matching objects from the second group. Note whether the child starts with the leftmost object and moves to the right (as one would reading English). Vary the patterns according to the experience and skill level of each child.

Variation: Build pattern games with hand claps, foot stomps, light flashes, or eye blinks.

Link the pattern

Here's what you need:

- colored construction paper
- presentation and storage container
- scissors
- glue
- paperclips or clothespins
- chart paper and colored markers

1. Prepare the activity by cutting the construction paper into strips 1-inch wide by 8 ½-inches long. Use paper in 3 to 5 colors. On chart paper, use markers to establish a pattern reflecting the colors of paper you've prepared.
2. Show children how to form a paper strip into a circle, add a dab of glue, and clip the circle until the glue dries. Encourage the children to make a chain, adding circles to their chains in the same sequence of colors on your chart. Note that the activity challenges manual dexterity as children have to hold the paper and clip it to secure.
3. Add to the challenge by drawing a longer sequence on the chart paper.

PHOTO BY SUSAN GAETZ



Variation: Encourage more acute observations of patterns by using printed wall paper strips—the same patterns in several colors and the same colors in different patterns.

Music, movement, and book ideas

Play *Simon Says* without words but by instead copying a leader's patterns like squat, hop, squat, squat, hop, clap.

I Know an Old Lady who Swallowed a Fly, She'll Be Comin' Round the Mountain, and *Bought Me a Cat* are cumulative songs that reinforce patterns (and memory).

Some noteworthy cumulative books that establish and reinforce patterns include *Bringing the Rain to Kapiti Plain* by Verna Aardema, *One Fine Day* by Nonny Hogrogian, and *The Napping House* by Audrey Wood.

Correspondence

Helping children recognize one-to-one correspondence—one spoon, one chair, one child—paves the way for understanding ordered sets and concepts like *more than*, *less than*, and *equal to*. Matching shoe and mitten pairs, setting a table for lunch, attendance tracking activities, and handing out name tags for a field trip are examples of everyday correspondence activities.

One space, one object

Here's what you need:

- discarded ice cube trays
- small loose parts like ceramic tiles, buttons, or beads
- presentation and storage container

1. Plan to work with one or two

- children at a time.
2. Place the tray on a table parallel to the child's body.
 3. Put one object in the first, upper left compartment, saying, "One space, one object."
 4. Ask the child to choose a matching object and put it in the leftmost lower compartment, repeating, "One space, one object."
 5. Repeat, filling all compartments with matching pairs in upper and lower compartments of the tray.
 6. Build on the activity by filling all the upper compartments before asking the child to put the matching object in the lower compartment.

Fasten the pin

Here's what you need:

- 5 10-inch squares of felt
- 5 large safety pins or clothespins
- permanent marker
- presentation and storage container

1. Prepare the activity by labelling the felt squares with the numerals 1 through 5. Print in large block style positioning the numerals at the lower left corner, about 3 inches from the edge. Under the numeral, draw dots that correspond to the numeral. The activity will support numeral recognition, encourage counting the dots that correspond to the written numeral, and offer a physical activity that reinforces the correspondence.
2. Share the squares with one or two children. Talk with them about the numerals and count the dots together.

3. Show the safety pins and demonstrate how they work. Let the children practice opening and closing the pins before pulling them through the fabric. If you have safety concerns, use squeezing clothespins instead of the safety pins for a similar fine-motor activity.
4. Discuss one-to-one correspondence and show how to put two pins on the square labeled with the numeral 2 and with two dots in the corner, for example.
5. Add squares and pins for numbers 6 through 10 as children are ready.

Spatial relationships

Spatial relationships describe the position two or more objects have to each other—*under*, *near*, *in front of*, *behind*, *on top of*, or *on the bottom*, for example.

Toddlers are often introduced to stacking cups and graduated rings to build the ability to see an object in space. Later, shape sorters—boxes with shaped holes and matching pegs—reinforce the skill. Objects have dimension and size. Puzzles are a classic material used for exploring spatial relationships. Wooden 3-piece inset puzzles are common in toddler classrooms, and many adults enjoy the relaxation that comes with thousand-piece jigsaw puzzles that picture common objects like hundreds of pencils in a pile and the abstract art of Jackson Pollock.

Where's the figure?

Here's what you need:

- 2 clear plastic cups for each child
- 1 small animal or human figure
- list of teacher prompts

1. Prepare the activity by making a list of spatial relationship words and phrases like *under*, *above*, *in front of*, *behind*, *under*, *inside*, *between*, *next to*, and *on top of*, for example.
2. Gather children at a table or on the floor.
3. Invite each child to choose a figure. A volunteer can hand 2 cups to each child in the group.
4. Invite the children to place their figures in the correct position according to what you call out. For example, when you say *under*, the children place the figure under a cup; when you say *between*, the children position a cup on either side of the figure.

Show me where

Here's what you need:

- sheets of cardstock
- scissors

- camera and printer
- glue
- marker
- presentation and storage container
- 4 cloth napkins
- 4 small markers like clothespins, paperclips, or counting bears

1. Prepare this activity by taking pictures of children in a variety of positions (spatial relationships) both indoors and out. Download and print the photos. Cut sheets of cardstock in half to make 5 ½ by 8 ¼ strips. Glue one photo to each piece of paper and write a caption for each. For example, "Henry on top of the slide"; "Magrette under the table"; "Mari in front of Pete"; "Jake in the middle of the circle"; "Kari next to the easel," and so forth.

2. Share the photos and read the captions with a small group of children.
3. Show how children can use the napkins and markers to duplicate the spatial relationships shown in the photos. For example, the napkin can be on top of the marker or the marker can be in the middle of the napkin. Help children understand the universality of relationships even when the people and objects change.

Music, movement, and book ideas

We're Going on a Bear Hunt (listen to Michael Rosen share his book at <https://youtu.be/0gyI6ykDwds>), *Looby Loo*, and *The Hokey Pokey* are movement activities that reinforce spatial relationships and vocabulary.

Share *Rosie's Walk* by Pat Hutchins or the folk tale *The Three Billy Goats Gruff* (see the 2017 retelling, illustrated by Caldecott medalist Jerry Pinkney). Build a creative drama activity in which children take turns playing different characters.

References and resources

- Copley, J. V. (2000). *The young child and mathematics*. Reston, VA & Washington, DC: National Council of Teachers of Mathematics and the National Association for the Education of Young Children.
- Copley, J. V. (2004). *Showcasing mathematics for the young child: Activities for three-, four-, and five-year-olds*. Reston, VA: National Council of Teachers of Mathematics.
- Mokros, Jan (1996). *Beyond facts*

PHOTO BY SUSAN GAETZ



-
- and flashcards: Exploring math with your kids.* Portsmouth, NH: Heineman.
- Moomaw, S. & Hieronymus, B. (1995). *More than counting: Whole math activities for preschool and kindergarten.* St. Paul, MN: Redleaf Press.
- National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. Retrieved on Jan. 20, 2020 at www.nctm.org/standards/.
- Wilburne, J., Keat, J., & Napoli, M. (2011). *Cowboys count, monkeys measure, and princesses problem solve: Building early math skills through storybooks.* Reston, VA: National Council of Teachers of Mathematics. ■