The Importance of Early Numeracy Skills

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Julie Wagner

Elementary Mathematics Specialist

OSPI

Introductions

- Introduce yourself, tell us what you do, and give us one word you would use to describe young preschool children.

Goals

- To review recent research on early numeracy and what it suggests
- To learn about early numeracy concept trajectories

Why numeracy skills?

- Want children prepared for school
- Changing times and economic need
- Ticket to a sustainable job
- Ability to persevere in problem-solving, reason abstractly and quantitatively, construct viable arguments and critique the reasoning of others
- Predicts later achievement

The Piaget problem

- Until children can conserve number, counting is meaningless.
- To understand counting, must understand that each number includes those that came before. Students have to produce number words in sequence and sequence the objects they count so each object has exactly one count.
- Much can be learned about counting and number before this is mastered.

Adapted from *Learning and Teaching Early Math: The Learning Trajectories Approach*- Clements & Sarama - 2009

Partial result of Piaget

- Emphasis in early years away from mathematics and towards a strong literacy foundation.

What does the research say?

A meta-analysis

School Readiness and Later Achievement, Duncan, et al, Developmental Psychology, 2007.

The strongest predictors of later achievement are school-entry math, reading, and attention skills. ***Early math skills have the greatest predictive power****. By contrast, measures of socio-emotional behaviors were generally insignificant predictors of later academic performance, even among children with relatively high levels of problem behaviors.*

How does this work?

- What numeracy skills children know when they enter kindergarten and first grade predicts their mathematics achievement for years to come.
- What they know in math predicts their *reading* achievement later.

But what about literacy?

- Early knowledge of literacy predicts later reading ability, but that's all.
- Since numeracy skills predicts later math *and* later reading ability, mathematics appears to be a core component of cognition.

What does the research say?

Review of research

Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity, National Research Council, 2009.

The committee found that, although ***virtually all young children have the capability to learn and become competent in mathematics****, for most the potential to learn mathematics in the early years of school is not currently realized. This stems from a lack of opportunities to learn mathematics either in early childhood settings or through everyday activities in homes and in communities.*

The preschool child

- Natural curiosity about everything
- As early as 18 months, children begin recognizing geometric shapes and develop systems for locating objects in space.
- Very early in life, have a limited ability to discriminate sets of different sizes from each other (2 versus 3), develops this skill for larger sets over time
- From an early age, understand the concept of addition and subtraction
- If children can learn ‘tyrannosaurus rex’, they should have no problem with ‘hexagon’ or ‘symmetrical.’

- Adapted from *Mathematics Education for Young Children: What IT IS and How to Promote It*, Ginsburg, Lee, Boyd,

The preschooler's brain

- Innate number sense
- Brains develop most when challenged with complex activities and not with rote learning
- Preschoolers do not perceive situations, problems, or solutions the same way adults do
- Young students do not see the world as separate subject areas.

Adapted from *How the Brain Learns Mathematics,* David A Sousa, 2008

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Pre-K children's daycare

- Center-based Head Start
- Child care centers
- Family child care homes
- Friends and family

What does the research say?

Article by NCTM President

- *A Missed Opportunity: Mathematics in Early Childhood,* Henry Kepner, NCTM Summing Up, February 2010.

  Prior to kindergarten, many children have the interest and capacity to learn meaningful math and acquire considerable mathematical knowledge. Many early childhood programs do not extend children's mathematical knowledge. Instead, they have these young students ***repeat the same tasks in varied settings without posing challenges*** *that would push them to the next level.*

What makes for high quality mathematics in early childhood?

- Does not involve pushing early elementary arithmetic onto younger children.
- Allows children to experience mathematics as they play in and explore the world.
- Observing the child and asking guiding questions that help them build their knowledge along a trajectory.

What does the research say?

Social policy report

Mathematics Education for Young Children: What It Is and How to Promote It, Ginsburg, Lee, & Boyd, Society for Research in Child Development, 2008.

- *Cognitive research shows that young children develop an extensive everyday mathematics and are capable of learning more and deeper mathematics than usually assumed.*
- ***Typically, early childhood educators are poorly trained to teach mathematics,*** *are afraid of it, feel it is not important to teach, and typically teach it badly or not at all.*

Minimum educational requirements for lead teachers in state-funded Pre-K

- Bachelor's Degree with training or certification in early childhood education – 20 states
- Bachelor's degree with training or certification in early childhood education in certain settings only – 8 states
- Bachelor's degree without training or certification in early childhood education – 2 states
- Training or certification in early childhood education – 9 states
- High school diploma – 1 state
- No state-funded pre-k program – 10 states

Research demonstrates that teachers with training in early childhood development are better equipped to facilitate young children's language-, cognitive- and social-skills development.

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FEAR of MATHEMATICS!

- Many teachers avoid teaching mathematics because of their own negative early experiences with mathematics.

Talk to your neighbor

- Step 1: Find a partner.

- Step 2: Take a few minutes for each person to share a personal story related to a math experience during childhood.

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Typical time spent on numeracy

- Not a lot of information out there
- National Center for Early Development and Learning (NCDEL) in two studies of state-run facilities, found children:
  - exposed to math 6 percent of the time,
  - occurring during whole-group activities;
  - embedded in other content
  - teachers focused on student performance of a discrete skill or display of factual knowledge
  - less often exposed to instruction that was conversational, interactive, and focused on understanding and problem solving

Adapted from *Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity* – National Research Council - 2009t

So what are the early numeracy skills?

Good news

- We know much more than we did in the past about how children learn and what they need to learn.
- It is within our abilities to close the achievement gap with good preschool development.

Learning trajectories

- Natural developmental progressions in learning and development.
- Have a mathematical big idea, a path for learning, and instructional tasks that match each part of that path for learning.
- Follow the mathematics of children – their way of thinking.

Adapted from *Learning and Teaching Early math: The Learning Trajectories Approach* – Clements and Sarama - 2009

Numeracy Readiness Skills

Three key areas:

- Number and operation
- Shape
- Measurement

Number and operation

Meanings of the word “count”

If we ask children to count, they may just start in “one, two, three,….” when we want them to tell us “how many.” Understanding the difference takes time.

Question

What must a child know in order to be able to ‘count’ correctly?

Number and operation

Concepts in counting:

- Recognize counting words
- The sequence of numbers
- One-to-one correspondence
- Cardinality
- Reverse of cardinality

Number and operation

One-to-one correspondence

Children have to know sequence of numbers and remember the sequence and where they are in the sequence as they count in order to master one-to-one correspondence – assigning one, and only one, number to each object in a group.

Number and operation

The sequence of numbers:

1-10

11-13, 15

14, 16-19

20-29

30-39

Number and Operation

Cardinality

Child moves from just saying the number sequence to understanding that the last number stated answers the question, “How many?”

Number and Operation

Reversal of cardinality

Child can be asked to, “Give me eight blocks,” and is able to count out the correct amount. Why would this be more difficult?

Counting trajectory

Age	Developmental Progression
late 1	Chants “sing-song” or sometimes indistinguishable number words
2	Verbally counts with number words, not necessarily in correct order above “five”
	If knows more number words than number of objects, rattles them off quickly at end. If more objects, “recycles” number words
3	Verbally counts to ten with some correspondence
Later 3	Keeps one-to-one correspondence between counting words and objects for at least small groups. May recount if asked a second time, “How many?’
4	Accurately counts objects in a line to 5 and answers the “How many?” question with the last number counted

Age	Learning Progression
Later 4	Counts arrangements of objects to 10. May be able to tell the number just after or just before another number, but only by counting from 1
	Counts out objects to 5
5	Counts out objects to 10 and beyond, keeps track of objects that have or haven't been counted
	Gives next number (usually to 20 or 30), separates decade and one parts of a number
	Recognizes errors in other's counting

Adapted from *Learning and Teaching Early Math: The Learning Trajectories Approach*, Clements & Sarama, 2009

Number and operation

Components of Operation

- Subitizing
- Comparison words
- Modeling

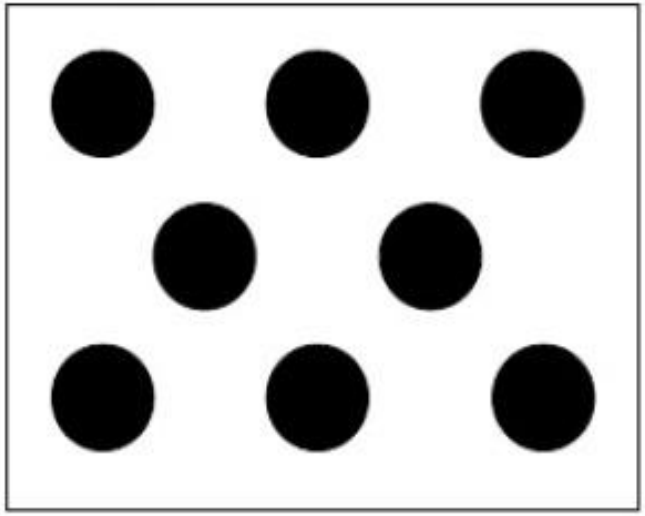
Research finding

Three pictures hang in front of a six-month-old child. The first shows two dots, the others one dot and three dots. The infant hears three drumbeats. Her eyes move to the picture with three dots.

Research shows this is one of the main abilities very young children should develop. Why?

Do you have it? Where do you use it?

Number and operation



What did you see?

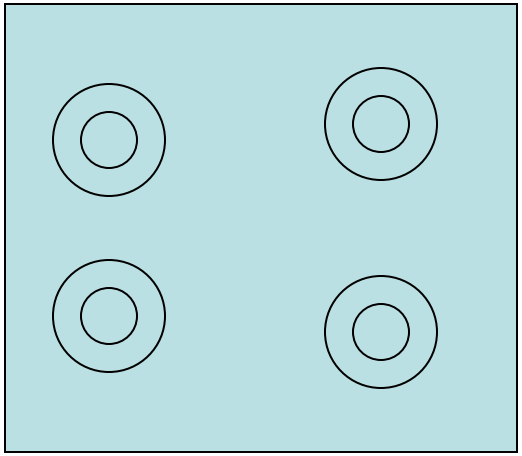
Number and operation

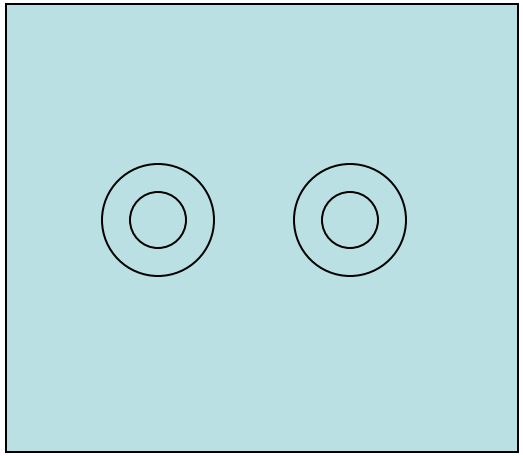
Subitizing

Knowing how many are in a collection without counting.

What is its role in operation?

Number and operation – Quantity comparison





Number and operation

Comparison words

- Bigger, smaller
- Longer, shorter
- Less, more
- Lighter, heavier

Comparison trajectory

Age	Developmental Progression
1	Puts objects, words, actions in one-to-one or one-to-many correspondence
2	Implicitly sensitive to the relation of “more than/less than” involving very small numbers
	Compares collections that are quite different in size. If same size, numbers must be small (one or two)
3	Compares collections of 1-4 items verbally or nonverbally. Has to be same item

Age	Learning Progression
4	Compares groups of 1-6 by matching, not the same objects.
	Accurately counts two equal groups, but the more spread out, or larger, will be more
5	Compares with counting, even when larger collection's objects are smaller; later, figures out *how many* more or less
	Names a small number for sets that cover little space and a big number for sets that are spread out

Adapted from *Learning and Teaching Early Math: The Learning Trajectories Approach*, Clements & Sarama, 2009

Number and operation

Modeling

Model or act out change situations that are said in words.

Operation trajectory

Age	Developmental Progression
1	Sensitivity to adding and subtracting perceptually combined groups. No formal adding
2 - 3	Adds and subtracts very small collections nonverbally.
4	Finds sums for joining problems up to 3 + 2 by counting –all with objects.
4-5	Finds sums for joining and part-part-whole by *direct modeling, counting-all with objects.* Solves take-away problems by separating with objects.

Adapted from *Learning and Teaching Early Math: The Learning Trajectories Approach*, Clements & Sarama, 2009

Early numeracy skills in action

- Counting to10
- Griffy Counts

Be prepared to talk about what you observe.

Shape

- Recognition of basic shapes
- Application to world around us
- Classification and sorting

Shapes trajectory

Age	Learning Progression
0-2	Compares real-world objects and says whether they are the same or different
	Matches familiar shapes
	Matches familiar shapes with different sizes
	Matches familiar shapes with different orientations
3	Recognizes and names squares and circles, less often triangles
	May rotate shape to mentally match to a prototype
	Judges two shapes the same if they are more visually similar than different

Age	Learning Progression
3-4	Matches a wider variety of shapes with *same size and orientation*
	Matches a wider variety of shapes with *different sizes and orientations*
4	Recognizes some less typical triangles, some rectangles but not rhombuses
	Says two shapes are the same after matching one side on each
	Looks for differences in attributes, but may examine only part of a shape
4-5	Recognizes more objects, looks for differences in attributes
5	Names a variety of shapes and classifies by an attribute or two

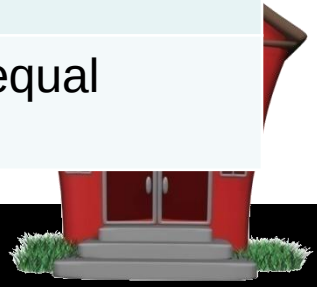
Adapted from *Learning and Teaching Early Math: The Learning Trajectories Approach*, Clements & Sarama, 2009

Measurement

- Assigns a number to a measureable attribute of an object, usually length, weight, capacity or mass.
- Young children can compare the values grossly.

Measurement trajectory

Age	Learning Progression
2	Does not identify length as attribute
3	Identifies length/distance as attribute, may understand length as an absolute descriptor (e.g., all adults are tall), but not as a comparative
4	Physically aligns two objects to determine which is longer or if they are the same length
	Compares the length of two objects by representing them with a third
5	Order lengths, marked in 1 to 6 units
6	Lays units end to end, may not recognize the need for equal length units



*i*Adapted from Learning *and Teaching Early Math: The Learning Trajectories Approach*, Clements & Sarama, 2009

How do children learn best?

Let them play!

Listen to what they say.

Think of the progressions.

Ask questions that further their understanding.

Gauging learning

Gauging

- ✓ What things children already know and understand
- ✓ What things could be understood with more practice and experience
- ✓ What things are too difficult without further groundwork

Adapted from *Principles and Recommendations for Early Childhood Assessments,* The National Education Goals Panel, 1998, pg 9

Current OSPI efforts

- WaKids Inventory
- WA Early Learning Plan – September 2010 – Strategy #11
- http://www.k12.wa.us/EarlyLearning/default.aspx

Reflections and Questions

Thank you.

Julie.Wagner@k12.wa.us