Designing Instruction & Assessment to Support Student Achievement: Early Mathematics

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CHANGING MINDS

Session Objectives

- Discuss the importance of early mathematics instruction
- Review the status of early mathematics quality
- Discuss best practices in early mathematics instruction and assessment
- Detail a sample learning trajectory for early mathematics

Why Early Mathematics?

- Studies show that very young children are capable of thinking mathematically (Gelman, 2000; Gelman & Gallistel, 1978)
- Knowledge Gap (U.S. vs International; income classes) (Geary et al., (1993)
- Success in early mathematics predicts success in: (a) later mathematics, (b) later reading, and (c) oral language development (Duncan, 2007; Duncan & Magnuson, 2011; Lerkkanen et al., 2005)
- Mathematics is cognitively foundational (Clements, Sarama, & Baroody, 2013)

How are we doing currently in early math?

- Some studies have reported that 60% of 3-year-olds have no mathematical experiences (Tudge & Doucet, 2004; Farran et al., 2007)
- Observation studies of Pre-K and Kindergarten classrooms suggest that mathematics is often embedded in other activities and typically makes up less than 15% of the curriculum content (Clements & Sarama; 2011)
- Little growth in mathematics is observed and “destructive habits of mind” and misconceptions are cultivated (Farran et al., 2007; Munn, 2006).
- Poor mathematics instruction is most harmful to poor children, children with linguistic differences, and children with MD/LD (Nasir & Cobb, 2007; Berch & Mazzocco, 2007).
- Greatest difficulty in early mathematics is our culture that devalues mathematics and depends on tradition rather than evidence (Clements, Sarama, & Baroody, 2013).

Pathways of Cognitive Development

	Infants (0–8 months)	Older Infants (8–18 months)	Toddlers (18–36 months)	3-year olds (36–48 months)	Pre-kindergartners (48–60 months)
CLASSIFICATION and PATTERNS	**Turns objects over to look at them** and handle them from different positions	**Stacks** blocks or objects	**Sorts/matches toys or objects** that are alike	**Sorts objects that are the same and different** **Copies simple patterns**	**Sorts objects and describes what makes them the same and different** Recognizes and creates patterns
GEOMETRY and SPATIAL SENSE		**Plays with a shape sorter**	**Moves objects into different positions** **Turns puzzle pieces different ways to complete puzzle**	**Names basic shapes** **Begins to use some position words** (*on top, under*) **Completes simple puzzles**	**Names and creates common shapes** **Names and understands position words and concepts** **Completes puzzles and creates new shapes**
MEASUREMENT		**Enjoys taking objects in and out of containers**	**Understands size differences** (*"too big" or "too small"*) **Pours, scoops, and plays with sand and water**	**Can use tools to measure** (*scoop water into bucket, string to determine length*)	**Recognizes and compares amounts and lengths** (*who is taller?, how much to fill bucket?*)
NUMBER SENSE		**Asks to continue** a game by signing or saying "more"	**Counts objects while pointing to each one** and saying number	**Uses numbers and counting concepts in daily life** (*can identify more or less when comparing two groups of objects*)	**Can recite 1 to 30; counts 1–10** (*one-to-one correspondence*) **Can use materials to add or subtract 1–5** (*"I have four blocks and add one more, now how many?"*)

For a more detailed chart of child skills and behaviors, visit the *Texas Infant, Toddler, and Three-Year-Old Early Learning Guidelines* and the *Revised Texas Pre-kindergarten Guidelines*: www.earlylearningtexas.org

Remember that skills can overlap across age ranges because children develop at their own rate.

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3-year olds (36–48 months)	Pre-kindergartners (48–60 months)
Sorts objects that are the same and different **Copies simple patterns**	**Sorts objects and describes what makes them the same and different** Recognizes and creates patterns
Names basic shapes **Begins to use some position words** (*on top, under*) **Completes simple puzzles**	**Names and creates common shapes** **Names and understands position words and concepts** **Completes puzzles and creates new shapes**
Can use tools to measure (*scoop water into bucket, string to determine length*)	**Recognizes and compares amounts and lengths** (*who is taller?, how much to fill bucket?*)
Uses numbers and counting concepts in daily life (*can identify more or less when comparing two groups of objects*)	**Can recite 1 to 30; counts 1–10** (*one-to-one correspondence*) **Can use materials to add or subtract 1–5** (*"I have four blocks and add one more, now how many?"*)

Appendix A

Curriculum Focal Points and Connections for Prekindergarten

The set of three curriculum focal points and related connections for mathematics in prekindergarten follow. These topics are the recommended content emphases for this grade level. It is essential that these focal points be addressed in contexts that promote problem solving, reasoning, communication, making connections, and designing and analyzing representations.

Prekindergarten Curriculum Focal Points	Connections to the Focal Points
Number and Operations: **Developing an understanding of whole numbers, including concepts of correspondence, counting, cardinality, and comparison** Children develop an understanding of the meanings of whole numbers and recognize the number of objects in small groups without counting and by counting—the first and most basic mathematical algorithm. They understand that number words refer to quantity. They use one-to-one correspondence to solve problems by matching sets and comparing number amounts and in counting objects to 10 and beyond. They understand that the last word that they state in counting tells "how many," they count to determine number amounts and compare quantities (using language such as "more than" and "less than"), and they order sets by the number of objects in them.	***Data Analysis:*** Children learn the foundations of data analysis by using objects' attributes that they have identified in relation to geometry and measurement (e.g., size, quantity, orientation, number of sides or vertices, color) for various purposes, such as describing, sorting, or comparing. For example, children sort geometric figures by shape, compare objects by weight ("heavier," "lighter"), or describe sets of objects by the number of objects in each set. ***Number and Operations:*** Children use meanings of numbers to create strategies for solving problems and responding to practical situations, such as getting just enough napkins for a group, or mathematical situations, such as determining that any shape is a triangle if it has exactly three straight sides and is closed. ***Algebra:*** Children recognize and duplicate simple sequential patterns (e.g., square, circle, square, circle, square, circle,...).
Geometry: **Identifying shapes and describing spatial relationships** Children develop spatial reasoning by working from two perspectives on space as they examine the shapes of objects and inspect their relative positions. They find shapes in their environments and describe them in their own words. They build pictures and designs by combining two- and three-dimensional shapes, and they solve such problems as deciding which piece will fit into a space in a puzzle. They discuss the relative positions of objects with vocabulary such as "above," "below," and "next to."	
Measurement: **Identifying measurable attributes and comparing objects by using these attributes** Children identify objects as "the same" or "different," and then "more" or "less," on the basis of attributes that they can measure. They identify measurable attributes such as length and weight and solve problems by making direct comparisons of objects on the basis of those attributes.	

Source: Reprinted from *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence* (Reston, Va.: National Council of Teachers of Mathematics, 2006, p. 11).

Best Practices for High Quality Teaching in PreK

- Build instruction from learning trajectories moving from concrete to abstract (Clements & Sarama, 2009; Rittle-Johnson et al., 2001).
- Use explicit teaching (modeling, guided practice, independent practice; I do it-We do it-You do it) (Gersten et al., 2009; Bryant et al., 2008; Kirschner et al., 2006)
- Create opportunities for meaningful practice (Clements et al., 2013; Lerkannen et al., 2012)
- Pair language development with mathematical concepts and skills (Ginsburg et al., 2008)
- Ask clarifying “why” and “how do you know” questions (Clements et al., 2013)
- Use planned tasks and observation to assess mastery (Black et al., 1998).

Learning Trajectory – Number (Clements & Sarama, 2009)

	Verbal Subitizing	Meaningful Counting	Magnitude Comparisons	Adding and Subtracting
Goal/Concept				
Language				
Instructional Example				
Assessment				

Helping Families-Helping Children

- Coach and encourage families to:
  - Discuss numbers 0-10 consistently starting early
  - Talk to children about mathematical ideas during play
  - Use number games and board games that involve learning trajectories
  - Use number in daily activities
  - Do puzzles
  - Discuss equal sharing