Great Source

Every Day Counts®
Everyday in Pre-K: Math

Research Base

Exposing children to early math concepts in a developmentally appropriate way helps them acquire the skills they need to be successful in school.

In order for all children to succeed, they need to have well-designed materials that are age appropriate and are administered by qualified teachers. Children of preschool age have intuitive understandings about mathematical concepts (Baroody & Benson, 2001; Baroody & Wilkins, 1999). "In free play, they are capable of spontaneously engaging in various and sometimes surprisingly advanced mathematical activities" (Ginsburg, Inoue, & Seo, 1999). This knowledge is connected to their understanding of counting (Kilpatrick, 2001). With the proper approach, these understandings can form the foundation for formal mathematical learning.

There are several reasons for including mathematics in the preschool classroom. Preschool children have a natural curiosity about mathematics, especially counting and geometry (Baroody & Wilkins, 1999). Mathematical literacy is necessary for socioeconomic advancement in the 21st century and learning mathematics, especially patterns, supports language and reading literacy (Clements, 2003).

Continuous exposure to critical math concepts allows children to develop an understanding of important mathematical concepts over time and learn at an individual pace.

Not every child acquires mathematical understanding at the same time, the same pace, or through the same modality (Bowman, 2001). By presenting appropriate mathematical concepts to preschool children over an extended period of time rather than in discrete units, children can learn at their own pace.

Every Day in Pre-K: Math is designed to deliver content incrementally to promote continuous learning and understanding. Using Heibert and Carpenter's definition of understanding, "the structuring process that produces understanding is built on networks of mental representations that are built gradually as new information is connected to existing networks, or as new relationships are constructed between previously disconnected information" (Heibert & Carpenter, 1992).

This understanding thus promotes remembering. "Evidence from verbal learning and comprehension suggests that these modifications are made to bring the information in line with the person's current knowledge" (Rumelhart, 1975). That way, the information is represented by students in a way that fits with their existing network of knowledge. Making connections between new information and existing knowledge already represented in networks is one way of characterizing Bartlett's (1932) observation of a natural "effort after meaning." Memory, if viewed as a reconstructive process, involves the same cognitive activity as understanding: constructing connections between representations of new knowledge and existing knowledge" (Heibert & Carpenter, 1992).

Every Day in Pre-K: Math presents connections across several math strands daily. This enhances transfer of learning. "This configuration is supported by Thorndike's (1914) view of shared components. According to Thorndike, the degree of positive transfer from one task to another is a function of the number of elements that the tasks share. If many of the elements or components that make up the tasks are alike, then the transfer from one task to another is high" (Heibert & Carpenter, 1992). Instructional approaches that use multiple representations help children to understand mathematics as an integrated system, allowing children to more easily access information when they need it (Sophian, 1999).

Offering children multiple points of entry helps them construct mathematical knowledge.

By presenting appropriate mathematical concepts orally, visually, and kinesthetically, each child can move the information into long-term memory in a manner that works best for him or her. It is these deep and sustained interactions with key mathematical ideas that enable children to acquire mathematical understanding (NAEYC/NCTM, 2002).

The authors of *Every Day in Pre-K Math* used the information gleaned from brain research and the understanding that preschool children actively construct mathematical knowledge. Teachers of prekindergarten children need to understand that the perception of the world mathematically for children of this age is different from that of an adult (Clements in press) and quality teaching includes tuning into those differences. Activities in the program allow children multiple points of entry through a variety of modalities in activities that are connected, or related.

Daily whole-class discussion encourages social interaction and dialogic discourse which promote a deeper understanding of key concepts.

The five mathematical process standards—communication, reasoning and proof, connections, problem solving, and representation—are ways in which children can acquire and use content knowledge (NCTM, 2000). By making communication the centerpiece of *Every Day in Pre-K: Math*, preschool children can listen to their peers to learn and solidify their understanding through explanation, and teachers can listen and observe to assess learning (Copley, 2000).

Instruction through reflective discourse and collective reflection helps children achieve mathematical understanding. Whitin and Whitin discovered "[T]alking was an effective way for children to clarify their thinking, discuss new possibilities, [and]extend the thinking of others"(Whitin & Whitin, 2002; NCTM, 2000). Cobb states in his observations of first-grade students, "the children did not happen to spontaneously reflect on a prior activity at the same moment. Instead, reflection was supported and enabled by participation in

discourse" (Cobb, 1997). "Language has a distinctive orienting function (Maturana & Varela, 1980), and classroom discourse can exploit this function to orient students' attention to mathematical relationships of interest. . . . Communication among the students and teachers is enhanced because all participants can focus their attention on the same entities and relationships between entities. . . . In fact, the language used to talk with others about materials may be crucial for students in constructing relationships (Greeno, 1988b; Resnick & Omanson, 1987)" (Heibert & Carpenter, 1992). "The establishment of a classroom participation structure that provides students with opportunities to explain and justify different solutions allows teachers to build on students' contributions as they move toward desired pedagogical goals. This discourse is central to reform and makes possible students' development of mathematical beliefs and values that contribute to the development of mathematical beliefs and values that contribute to the development of their intellectual autonomy" (McClain & Cobb, 1999).

The teacher's role in initiating and shifting the discourse is critical. Open-ended questions are provided in the teacher's guide to promote thinking and reasoning, reflecting and understanding. Sample questions and sample discussions in the teacher's guide are provided to give the teachers guidance. "The teacher plays a proactive role in guiding the development of reflective discourse while simultaneously stressing that both such discourse is an interactional accomplishment and that students necessarily have to make an active contribution to its development. The teacher also needs to record the children's contributions" (Cobb, 1997; Shane, 1999). These records grow out of students' activity in a bottom-up manner. For example, records may include graphs, tracings of hands, different spatial configurations of two-dimensional figures or different configurations of a set quantity of objects. Getting children to talk about what they see and do helps to make their knowledge more explicit (Sophian, 1999).

Incorporating children's literature helps preschoolers make sense of the mathematics.

Literature selections are suggested for each month in *Every Day in Pre-K: Math*. By offering suggested literature that touches on mathematical concepts discussed during the month, the teacher has another tool for giving meaningful context to the mathematical concepts. Children may find these contexts relevant, familiar and interesting. They may relate to their prior knowledge or experiences. This in turn can be motivating and support memorization (Hong, 1999).

Using real-life data, everyday objects as manipulatives, and visual models to create patterns promotes students' problem solving ability.

Patterns pervade *Every Day in Pre-K: Math*. A variety of patterns, linear and non-linear, number patterns (counting), geometric patterns, two-step visual patterns (mittens and socks), patterns involving measurement

terms (order of objects by size), and rhythms and music are used in activities throughout the year. According to Ecnonmopoulos, being able to generalize about a pattern and use known information to predict unknown information is a powerful aspect of patterns. "Because our number system is built on a system of patterns and predictability, students must be able not only to identify the patterns that they see but also to give reasons and evidence for why the patterns exist" (Economopoulos, 1998). Young children can recognize, describe, extend, and create a wide variety of patterns through musical activities (Kim, 1999).

Developing number sense and computational fluency allows students to construct understanding internally.

Proportional thinking can begin in prekindergarten. By keeping track of the first one hundred days in school by counting fingers on tracings of the children's hands, the children begin to relate five fingers to one hand, ten fingers to two hands. Without using abstract symbolic notation, children begin to see a proportional relationship (Curcio & Schwartz, 1997).

Through a variety of structured daily activities, children develop number sense and computational fluency. Children are using manipulatives to compose and decompose number; sort, count and group objects; combine and compare quantities. While doing these activities, children are explaining what they see and making predictions and generalizations based on what they understand. "Taking the time to listen to other strategies is important … it is an opportunity for students who may not be as confident to hear a strategy that they can relate to, and also for students who consistently rely on one strategy to hear other strategies verbalized" (Sisul, 2002; Griffin, 2003). *Every Day in Pre-K: Math* uses a variety of physical and visual models to show number. Groups of five are represented by fingers colored in on a cutout of a hand. Quantities to nine are represented by circles arranged in domino configurations and ten frame configurations. Children are telling stories about quantities of classroom objects. They discuss the similarities and differences of the different representations for numbers. Teachers are guiding the children's discussions and encouraging them to reflect on their discoveries. These activities build oral language skill and good listening and thinking skills. The verbal and visual supports promote understanding of oral number words and cardinal number (Fuson, Grandau, & Sugiyama, 2001). "Counting and counting knowledge in its various forms is an integral aspect of young children's everyday life. Indeed, it could be argued that the construction of counting concepts and skills is the single most important element in preschooler's mathematical
development. Not only are counting competencies essential everyday 'survival skills' in their own right, they provide a basis for the development of number and arithmetic concepts and skills" (Baroody & Wilkins, 1999).

Subitizing, or "instantly seeing how many" is reinforced on a daily basis in *Every Day in Pre-K: Math*. Perceptual subitizing (i.e. instantly 'seeing' a set of three) (Clements, 1999) is the goal of the Make a Match

element. Each month children are given a set of cards to match. Initially small quantities are represented in standard domino or dice configurations. For the next few months, the size of the sets increases. Each time, the instruction is centered around the idea of adding 'one more.' Gradually the discourse moves toward conceptual subitizing, in which children recognize a visual model as a composite of parts of a whole (Clements, 1999). As the year progresses, the Make a Match cards include representations that are linear and eventually scrambled.

Spatial concepts and measurement concepts are also important skills for preschool children. Geometric and measurement attributes connect to language development at this age. Children are defining objects in their environment based on size, shape, and position. "As can be seen, then, spatial concepts and language are intimately related. As language and concepts develop, performance on spatial tasks has been shown to improve" (Hermer, 1994). Thus, it is important that young children be given numerous opportunities to develop their spatial and language abilities in tandem" (Greenes, 1999). "Shape concepts begin forming in the preschool years and stabilize as early as age six. Children can and should discuss the parts and attributes of shapes. Activities that promote such reflection and discussion include building shapes from components. We should encourage children to describe why a figure belongs are does not belong to a shape category" (Clements, 1999).

References

Baroody, A. J., and Benson, A. (2001, November). Early number instruction. *Teaching children mathematics*, 154-158.

Baroody, A. J., and Wilkins, J. L. M. (1999). The development of informal counting, number, and arithmetic skills and concepts. In J. V. Copley (Ed.), *Mathematics in the early years* (pp. 48-65). Reston, VA: National Council of Teachers ofMathematics.

Bartlett, F. C. (1932). *Remembering*. Cambridge: Cambridge University Press.

Clements, D. H. (1999). Geometric and spatial thinking in young children. In J. V. Copley (Ed.), *Mathematics in the early years* (pp. 66-79). Reston, VA: National Council of Teachers of Mathematics.

Clements, D. H. Mathematics in the preschool. *Teaching children mathematics*. In press.

Clements, D. H. (2003, February/March). Math matters: Building math skills leads to language literacy—and lifelong success. *Scholastic parent and child*, 13.

Clements, D. H. (1999, March). Subitizing: What is it? Why teach it? *Teaching children mathematics*, 400-405.

Cobb, P., Boufi, A., McClain, K., Whitenack J. (1997). Reflective discourse and collective reflection. *Journal of research in mathematics education*, 28(3) 258-277.

Committee on Early Childhood Pedagogy. (2001). *Eager to learn: Educating our preschoolers*, B. T. Bowman, S. M. Donovan, and M. S. Burns, (Eds.) National Academy Press.

Copley, J. V. (2001, October). The early childhood mathematics collaborative: Communities of discourse. *Teaching children mathematics*, 100-103.

Copley, J. V. (2000). *The young child and mathematics*. Reston: VA. National Association for the Education of Young Children and National Council of Teachers of Mathematics.

Cost, Quality, and Outcomes Study Team. (1995). *Cost, quality, and child outcomes in child care centers*. Denver, CO: Department of Economics, University of Colorado.

Curcio, F. R. and Schwartz, S. L. (1997, February). What does algebraic thinking look like and sound like with preprimary children? *Teaching children mathematics*, 296-300.

Economopoulos, K. (1998, December). What comes next? The mathematics of pattern in kindergarten. *Teaching children mathematics*, 230-233.

Fuson, K., Grandau, L., and Sugiyama, P. A. (2001, May). Achievable numerical understandings for all young children. *Teaching children mathematics*, 522-526.

Ginsberg, H., Noriyuki, I., and Kyoung-Hye, S. (1999). Young children doing mathematics: Observations of everyday activities. In J. V. Copley (Ed.), *Mathematics in the early years*, (pp. 88-99). Reston, VA: National Council of Teachers of Mathematics.

Greenes, C. (1999). Ready to learn: Developing young children's mathematical powers. In J. V. Copley (Ed.), *Mathematics in the early years*, (pp. 39-47). Reston, VA: National Council of Teachers of Mathematics.

Greeno, J. G. (1988). The situated activities of learning and knowing mathematics. In M. J. Behr, C. G. Lacampagne, and M. M.Wheeler (Eds.) *Proceedings of the tenth annual meeting of the PME-NA*, (pp. 481-521). DeKalb, IL: Northern Illinois University.

Griffin, S. (2003, February). Laying the foundation for computational fluency in early childhood. *Teaching children mathematics*, 306-309.

Hermer, L. (1994, March). Increasing flexibility for spatial reorientation in humans linked to emerging language abilities. Poster presentation. Cognitive Neuroscience Society. San Francisco, CA.

Hiebert, J. and Carpenter, T. P. (1992). Learning and teaching with understanding. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*. New York: Macmillan Publishing Company.

Hong, H. (1999). Using storybooks to help young children make sense of mathematics. In J. V. Copley (Ed.), *Mathematics in the early years*, (pp. 162-168). Reston, VA: National Council of Teachers of Mathematics.

Kilpatrick, J., Swafford, J. and Findell, B. (Eds.), (2001). *Adding it up: Helping children learn mathematics*. National Academy Press.

Kim, S. L. (1999). Teaching mathematics through musical activities. In J. V. Copley (Ed.), *Mathematics in the early years*, (pp. 146-150). Reston, VA: National Council of Teachers of Mathematics.

Lewis, A. C. (2003, March). Hi ho, hi ho, it's off to tests we go. *Phi Delta Kappan*. Retrieved from: http://www.pdkintl.org/kappan/k0303lew.htm

Maturana, H., and Varela, F. (1980). *Boston University Philosophy of Science Series*: Vol.42. Autopoieis and cognition. Dordrecht: D. Riedel.

McClain, K. and Cobb, P. (1999). Supporting students' ways of reasoning about patterns and partitions. In J.V. Copley (Ed.), *Mathematics in the early years*, (pp. 112-118). Reston, VA: National Council of Teachers of Mathematics.

McDill, E. L., and Natriello, G. (1999). The sociology of day care. In J.V. Copley (Ed.), *Mathematics in the early years*. (pp. 21-29). Reston, VA: National Council of Teachers of Mathematics.

National Association for the Education of Young Children and National Council of Teachers of Mathematics. (2002, April). *Early childhood mathematics: Promoting good beginnings*. Joint position statement.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*, (pp. 144-168). Reston, VA: National Council of Teachers of Mathematics.

Putnam, R. T., and Borko, H. (2000, January-February). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational researcher*, 4-13.

Resnick, L. B., and Omanson, S.F. (1987). Learning to understand arithmetic. In R. Glaser (Ed.), *Advances in instructional psychology*, vol. 3, (pp. 41-95). Hillsdale, NJ: Lawrence Erlbaum.

Rumelhart, D.E. (1975). Notes on a schema for stories. In D.G. Bobrow & A.M. Collins (Eds.), *Representation and understanding*, (pp. 211-236). New York: Academic Press.

Schwartz, S. (1996, March). Hidden messages in teacher talk: Praise and empowerment. *Teaching children mathematics*, 396-401.

Shane, R. (1999). Making connections: A 'number curriculum' for preschoolers. In J.V. Copley (Ed.), *Mathematics in the early years*, (pp. 129-134). Reston, VA: National Council of Teachers of Mathematics.

Sisul, J. S. (2002, December). Fostering flexibility with number in the primary grades. *Teaching children mathematics*, 202-204.

Sophian, C. (1999). Children's ways of knowing: Lessons from cognitive development research. In J. V. Copley (Ed.), *Mathematics in the early years*, (pp. 11-20). Reston, VA: National Council of Teachers of Mathematics.

Thorndike, E. L. (1914). *The psychology of learning*. New York: Teachers College.

Whitin, P. and Whitin, D. J. (2002, December). Promoting communications in the mathematics classroom . *Teaching children mathematics*, 205-211.

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