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Number Concept Development in Young Children

Mathematical skills are a prerequisite for success in our technological society. In order to learn first grade mathematics skills, such as addition and subtraction, a preschool child needs to master a set of pre-academic math concepts. The development of these pre-academic abilities, which consist of much more than rote counting, will be reviewed in the following article.

The dominant theories dealing with the development of mathematical skills are: Piagetian, Post-Piagetian, and information processing. Piaget (Piaget & Szeminska, 1952) stressed the role of the child's own activities for developing awareness of number properties as a foundation for understanding number concepts. These activities include classification, seriation (ordering things by size), matching and comparison. Because preschool children function within Piaget's pre-operational stage, comprehension of number concepts is not fully achieved during the preschool years. Post-Piagetian theorists (Inagaki, 1992) accept the Piagetian stages of development but put more emphasis on memorized skills. The information processing approach (Siegler, 1991) does not accept Piaget's stages and instead emphasizes the importance of providing interesting tasks to capture the child's attention for learning and to encourage repetition for overlearning of basic math skills. Current recommendations for a preschool mathematics curriculum incorporate all three of the above approaches (Althouse, 1994). The following basic skills are needed for success with first grade math.

Counting skill

Prior to first grade, counting is expected up to 10 or more (Brigance, 1977). According to Gellman and Gallistel (1978), five principles can be identified in children's counting.

1. ***The one-to-one principle*** means that the child uses only one number word for each object. Young children have a tendency to skip objects or to say two number words for the same object. Techniques for teaching this principle include reminding the child to count carefully and to touch each object with the finger. It is also helpful if the objects to be counted are put in a line in size order. Some deficits may interfere with the child's ability to demonstrate understanding of the one-to-one principle. An impulsive 5-year-old counting the 15 dots on the Wide Range Achievement Test-3 (WRAT-3; Wilkinson, 1993) may start carefully and later begin to skip dots. Children with a physical disability, even if aware of the importance of one-to-one correspondence, may make errors in counting small dots due to poor fine motor control and difficulties in eye–hand coordination, yet may count large circles or blocks correctly. The Brigance Diagnostic Inventory of Basic Skills (Brigance, 1977) and Wechsler Preschool and Primary Test of Intelligence – Revised (Wechsler, 1989) present stimulus items of larger size.

According to Piaget, a child develops an awareness of the importance of one-to-one correspondence by matching objects in everyday situations and realizing the importance of not omitting any item. For example, in setting the table the child provides a plate for mommy, a plate for daddy, a cup for mommy, a cup for daddy, etc.

2. The stable order principle means that the number words are used in fixed order. Here we are dealing with a memorized correct sequence in counting, the length of which increases with age. Often a 3-year-old can count up to 5, but a 5-year-old is expected to count correctly up to 10 or more. Stable correct order is only meaningful if applied with one-to-one correspondence; it is not enough that it be memorized. The stable order principle is not the same as the Piagetian concept of conservation of number, which consists of the child's awareness of and ability to explain that the number of objects does not change with a change in their configuration if nothing is added or taken away. Preschool children are still functioning in the earlier pre-operational stage and tend to make perceptually based judgments. For example, if they count 7 red blocks and match them with 7 blue blocks, establishing the equivalence of the two sets, and the blue blocks are spread in longer line they may think that there are more blue blocks.

3. The order irrelevance principle means that it does not matter which object is assigned a number first, but that all objects have to be counted. For the development of this principle, according to Piaget, the child has to realize from the experiences of classifying, matching and comparing different sets of objects in changing configurations, that the order in which they are counted is irrelevant but all the objects must be counted. For example, in the Stanford Binet 4th Edition (Thorndike, Hagen, & Sattler, 1986) Quantitative subtest, the child is expected to count configurations of dots on cubes.

4. The cardinality principle consists of the child's realization that the last number word used is the number of objects in the set. According to Piaget, to develop comprehension of cardinality the child needs to have a lot of experience with seriation and ordering of objects based on comparison of the differences between them. A pre-kindergarten child may easily order 3 objects, while kindergarten children can order 6 to 10 objects. Through ordering objects by size, the child becomes aware of the importance of a place in a series. Cardinality comprehension involves the awareness that number 5 includes a set of 5 objects and is bigger than the number 4 and smaller than 6. A 5-year-old child's correct answer to the question "How many?" may be a learned skill without an understanding of quantitative significance of the answer as indicating cardinality (Sophian, 1987). An understanding of an ordinal number will be indicated by the child's response to the request to show the fifth block, and cardinality by responding to the request "Give me 3 blocks" and "Give me 7 blocks" from a set of 10 blocks.

5. The abstraction principle means that a counting procedure can be applied to all kinds of things and even to groups. Encouragement to classify, compare, and count different sets of objects makes the child aware of how counting can be used. The child may count the number of children in the class, number of boys and girls, number of classes in school, and may match and count big and small blocks. Matching and counting items are included in the Peabody Individual Achievement Test – Revised (PIAT-R; Markwardt, 1989).

Mathematical vocabulary

For first grade readiness a child needs to know such terms as: more, less, the same, equal, as many as, how many, bigger, smaller, taller, shorter, between, before, after. On the PIAT-R (Markwardt, 1989) the child has to demonstrate his understanding of such terms by pointing to the correct pictures.

Problem solving

For first grade readiness this consists of the child's ability to solve math problems, usually by counting on his fingers. He has to be able to listen and to understand simple instructions. For example, a child may be asked, "If you have three lollipops and your friend gives you one more, how many lollipops will you have altogether?" or "If you have three pennies and you spend one of them, how many do you have left?" The Einstein Evaluation of School Related Skills – Kindergarten Level (Gottesman & Cerullo, 1996) and WRAT-3 (Wilkinson, 1993) present these kinds of items.

Writing and reading numerals

Children 4 and 5 years old may be interested and should be encouraged to recognize and write numerals (Althouse, 1994). By the end of kindergarten, children should be able to write numbers up to 10 and to recognize them (Brigance, 1997). To demonstrate that this is not only a memorized counting skill but meaningful knowledge, the child is expected to match the number of objects with correct numeral. The PIAT-R (Markwardt, 1989) presents this kind of item for young children.

Mathematical Giftedness

While excellence in language skills is readily recognized in preschool children, the same is not true for mathematical abilities. Are there ways to recognize that a preschool child is gifted in math? According to Szeminska (Hornowski, 1978), a young child with good aptitude for math is one who shows, more than other children of his age, an interest in, concentration, and persistence with tasks involving classification, ordering, and comparison and matching of objects. For example, a 5-year-old child may become involved in ordering 10 dolls by size and matching them with the proper size umbrellas. For a child of this age it is a very difficult task and most children will become tired of it or confused. Another sign of giftedness in math consists of a child's spontaneous and appropriate use of counting in situations where other children of his age usually do not do it. For example, in setting the table the gifted child may not need to match a cup for mommy, and a cup for daddy. The child instead knows that for 4 persons in the family 4 plates, 4 cups, 4 spoons, and 4 knives are needed. The child proceeds to count out those quantities. Another example is spontaneously using counting to compare or to verify two sets of objects, a task that is usually done by young children perceptually, based on appearance. These early signs of mathematical ability should be recognized and encouraged.

An increased awareness by preschool educators and parents, of the math concepts, as well as the skills that a young child needs to learn, and the resulting increased emphasis on conceptual, rather than purely rote aspects of math, will enhance children's learning in this important area.

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