An Exploratory Study of a Number Sense Program to Develop Kindergarten Students’ Number Proficiency

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Abstract
This study examined the effectiveness of a number sense program on kindergarten students’ number proficiency and responsiveness to treatment as a function of students’ risk for mathematics difficulties. The program targeted development of relationships among numbers (e.g., spatial, more and less). A total of 101 kindergarten students (not at risk: 22 control and 36 experimental; at risk: 18 and 25) from five classrooms in a high-poverty elementary school participated in the study. Using a quasi-experimental design, classrooms were randomly assigned to either the intervention (number sense instruction, NSI) or control condition. Results indicated significant differences favoring the treatment students on all measures of number sense (e.g., spatial relationships, more and less relationships, benchmarks of five and ten, nonverbal calculations) at posttest and on a 3-week retention test. Furthermore, the effects were not mediated by at-risk status, suggesting that NSI may benefit a wide range of students. Implications in terms of preventing early mathematical learning difficulties are discussed.

Keywords
mathematics, strategy instruction, at risk, prevention

Students with good number sense develop a quantitative intuition that helps them to solve problems in a flexible manner. They understand that numbers are representative of objects, magnitudes, relationships, and other attributes and are aware that numbers can be operated on, compared, and used for communication (Markovits & Sowder, 1994; National Council of Teachers for Mathematics [NCTM], 2000; National Research Council, 2001). In contrast, children with poor number sense have difficulties in discriminating between quantities and are at risk for later failure in mathematics (Berch, 2005; Gersten & Chard, 1999).

The pioneering work of Dehaene (1997) suggests that well before the development of formal symbols, children acquire prenumber experiences informally through interactions with parents and siblings before they enter kindergarten. That is, they develop some sense about numbers even before they learn to count. Later, children are able to reliably count and represent small numbers and use that knowledge to make quantity estimates (Gelman & Gallistel, 1978; Griffin & Case, 1997). Furthermore, there is evidence that “early verbal number competencies are necessary for extending knowledge with small numbers to knowledge with larger numbers and for learning school-based mathematics” (Jordan, Glutting, & Ramineni, 2010, p. 83). The prenumber abilities form the basis for the development of symbolic number sense (Feigenson, Dehaene, & Spelke, 2004).

Early number proficiency includes the ability to subitize small quantities, discern number patterns, compare numerical magnitudes and estimate quantities, count, and perform simple number transformations (Berch, 2005; Case, 1998). Many children’s learning difficulties in mathematics have been explained by problems related to counting, number comparisons, and set transformations (Geary, 1990; Mazzocco & Thompson, 2005). The work of Jordan and her colleagues (Jordan, Huttenlocher, & Levine, 1994; Jordan, Kaplan, Ramineni, & Locuniak, 2008) indicates that these number competencies “are highly sensitive to socioeconomic status, suggesting the importance of early input and instruction” (Jordan et al., 2010, p. 82). Specifically, children from low-income households do not perform as well as their middle-income peers on verbal number combinations and story problems involving addition and subtraction (Jordan et al., 1994). Furthermore, their use of counting strategies is less adaptive in that they do not avail

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