Number Sense Instruction: A Comprehensive Literature Review

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Abstract

This article summarizes the findings of research studies focusing on number sense instruction to improve mathematics competence of school going children. Twenty-three studies were located that met the inclusion criteria. Interventions gleaned from the review were categorized based on type of instruction (i.e., constructivist, explicit or a combination of the two). Treatment outcomes are discussed in relation to the various instructional approaches, student characteristics (e.g., grade, age), instructional features (e.g., materials, treatment length), assessment (formal, informal) and methodological features. Implications for classroom practice and future research directions are provided.

Keywords: number sense; literature review; constructivist approach; explicit instruction

1. Background

A strong sense of number and the quantity it represents is an integral part of all areas of life affecting successful functioning on the job, in school, at home, and in the community. Despite the importance of quantitative reasoning, mathematical difficulties are widespread among U.S. students (Dougherty, 2003; Ostad, 1998). Results of national and international assessments indicate that many students from United States experience difficulties in the areas of mental computation, estimation, and quantitative judgment, all of which are important components of the understanding of number (Greeno, 1991; National Council of Teachers of Mathematics, [NCTM], 2000; Tsao, 2011).

Knowledge about the structure of the number system is essential for students to perform computations in flexible and creative ways. While a robust sense of number is a major component of the mathematics curriculum in elementary and middle school, number sense is also crucial for the development of later mathematical thinking (NCTM, 2000). Number sense entails knowledge of counting, number patterns, magnitude comparisons, estimation, and number transformation (Berch, 2005). 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; NCTM, 2000; National Research Council, 2001, Tsao, 2011).

Mathematical knowledge is comprised of procedural and conceptual knowledge (Miller & Hudson, 2007). Traditionally, mathematics instruction has emphasized more basic skills (e.g., computation) instruction rather than higher order skills such as thinking, reasoning, and problem solving. Such a focus is viewed as being too narrow and likely to compartmentalize children’s numerical thinking (Case, 1989). Because this approach encourages rote learning of procedural knowledge, which in turn may lead to a weak understanding of concepts, mathematics reform was called for. This reform led to a new way of conceptualizing the teaching and learning of mathematics. With the publication of the NCTM’s Curriculum and Evaluation Standards for School Mathematics in 1989 and Principles and Standards for School Mathematics in 2000, the emphasis shifted from procedural knowledge and rote-driven computation to conceptual knowledge (Schroedel, 2002).

The notion of conceptual knowledge originated from the epistemological theory of constructivism. Constructivists hold the position that learners actively construct knowledge through their interactions in the world and efforts to make sense of those experiences (Ultanir, 2012). This is contrary to the traditional view that knowledge exists independently, outside of the learner, and must be transmitted to (or imposed on) the learner. Constructivist