



# RESEARCH AND RATIONALE FOR KENS MATH

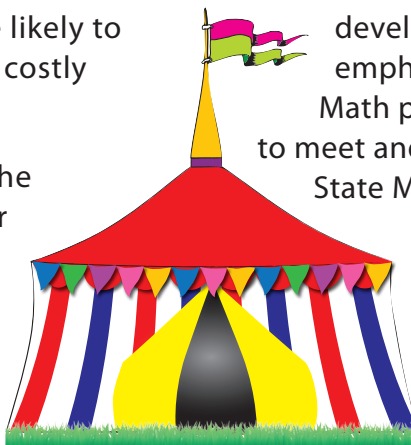


NCTM President Francis “Skip” Fennell called educators to action in his article in the NCTM bulletin titled, “Number Sense-Right Now.”<sup>1</sup> Dr. Fennell’s call to action becomes more urgent in light of recent studies that underscore the need for early instruction in number sense. In his review of multiple math research studies, Greg Duncan, Ph.D., suggests that the math ability of a student entering kindergarten is a good predictor of later math and reading achievement.<sup>2</sup> Additional research studies show that kindergartners who do not develop number sense while in kindergarten are highly likely to develop math difficulties in later grades.<sup>3,4,5</sup> These problems are likely to persist and require substantial and costly intervention.

KENS Math is a direct response to the NCTM’s President’s call to action for a program to develop number sense in our youngest students. KENS Math is a research and brain-based program that prepares young learners for a lifetime of

achievement in math. With its specific focus on helping preschool, kindergarten, and first grade students to develop number sense, KENS Math targets the key components of number sense that researchers associate with math achievement. These number sense skills include the ability to “subitize,” or instantly know a set of numbers without counting; the ability to quickly know the sum of two or more numbers; and the ability to estimate the placement of a number on a number line. In addition, KENS Math makes use of the latest research which highlights the role of basic board games as a tool to promote development of number sense.<sup>6</sup> With an emphasis on number sense in the KENS Math program, students are prepared to meet and often exceed the Common Core State Math Standards and the NCTM Focal Points.

KENS Math began as a solution to a common problem faced by many intermediate-level teachers. Simply put, there

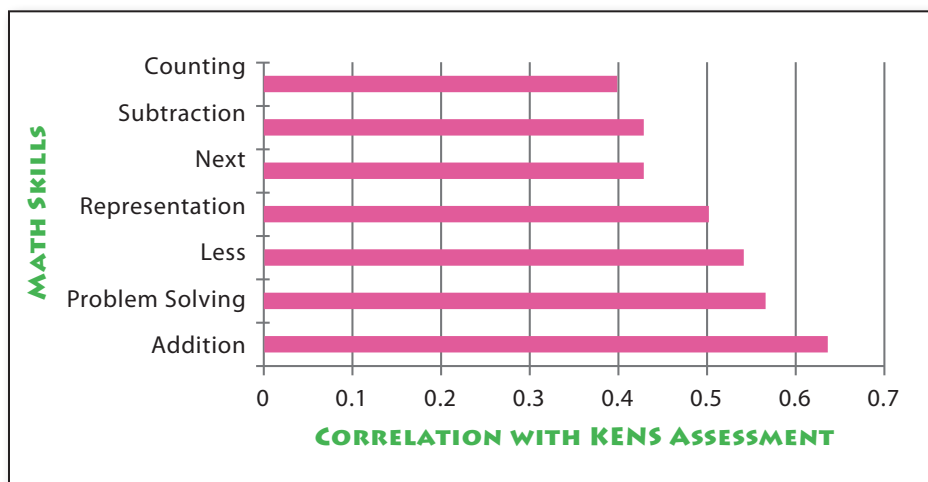


are too many third, fourth and fifth grade students who struggle to comprehend simple math concepts and facts. As the students move up in grade each year, their struggles with math continue or get worse. As an elementary principal, the author of KENS Math, Dr. Ken Newbury, developed an action research plan to determine which children were likely to struggle with math and what components of number sense related to later math achievement. He focused on kindergartners as a starting ground for preventive intervention and teaching. The result of this research was the development of the KENS assessment, a one-minute test for kindergarten students that could identify students who were likely to struggle in math.

The KENS assessment is composed of 10 challenge problems that measure a student's ability to subitize one to five dots quickly. While observing students' problem solving strategies, it became clear that students who correctly completed the 10 problems used a combination of subitizing and number combinations based on the array of dots on each of two sheets. Students who made mistakes displayed poor subitizing skills and did not successfully combine number sets. An analysis of the results showed a very strong correlation between the number of errors a student made on the KENS assessment and their ability to answer correctly on other math challenges. Table 1 exhibits the results of a Pearson-Product Moment Correlations from the KENS assessment and other common components of number sense including counting, identifying numbers, knowing what number comes before and after a single digit number, and simple addition

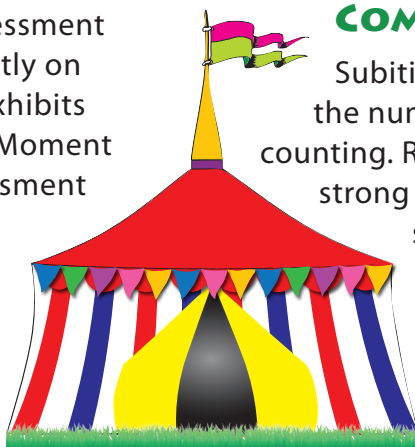
and subtraction problems. There was not a significant correlation between gender and the total number of errors on the KENS assessment. However, there was a slight correlation between social economic status and the total number of errors on the KENS assessment. A later study compared student achievement on a first grade state math diagnostic test taken at the end of the year with the previous year's KENS assessment scores. These scores also showed that there is a strong correlation between the number of errors made by kindergarten students on the KENS assessment and their achievement in first grade math.

The specific components of KENS Math are based on current research findings. A brief description of the supportive research is presented here related to the core number sense skills developed by KENS Math.



### SUBITIZING AND NUMBER COMBINATION

Subitizing is the ability to quickly identify the number of items in a small set without counting. Researchers have demonstrated a strong relationship between subitizing skill and math achievement including a recent study with over 500 kindergarten students.<sup>7</sup> Subitizing skill has also been shown to be a reliable predictor of later math achievement.<sup>8</sup>



Educator Douglas H. Clement addressed a key question related to subitizing in his article, "Subitizing: What is it? Why teach it?"<sup>9</sup> Clement concluded that subitizing can play an important role in the development of basic math skills including addition and subtraction skills. In his article, Clement distinguishes between the perceptual subitizing common in very young children and conceptual subitizing. When a child quickly perceives that three dots are more than two dots, and names the total number of dots, the child is using perceptual subitizing. Because we are biologically limited to quickly subitize no more than four or five dots, it would require a conceptual understanding of number to know that four dots and two more dots make six dots.

Conceptual subitizing is similar to the ability to combine small sets of numbers or number combinations. This can be accomplished in several ways. One way is to memorize a specific pattern of numbers. When a child learns that two columns of three on a die make six, the child is memorizing a pattern for six. With explicit training, however, students can combine numbers non-verbally to determine the sum of two sets of numbers.

As Clement suggests, the arrangement of dots or items in a set can make knowing "how many" difficult or easy. Dots that are too tightly arranged or placed in a circle are more difficult to subitize than dots that are placed in a line or in a rectangle. In KENS Math, the arrangement of dots is purposefully created to provide a measured degree of challenge. In most cases, a linear arrangement is used, because it models a number line.

Additional research studies have documented the success of teaching older students to subitize. In one study, students were trained to recognize sets of numbers presented on a computer screen

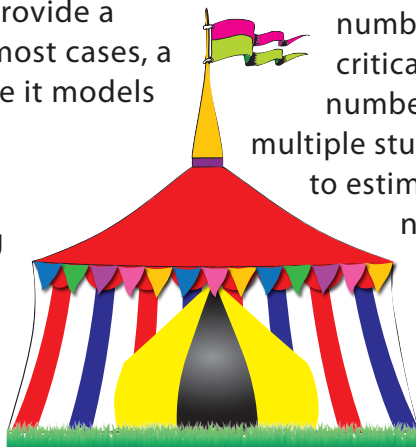
for a fraction of a second. With practice, these students developed the ability to subitize. These students also demonstrated increased arithmetic skill without explicit training!<sup>10</sup> In KENS Math, the placement of dots, the gradual increase in challenge, and the intentional training of subitizing and number combinations is designed to take advantage of these key research findings to further support each student's number sense development.

## NUMBER LINE, MAGNITUDE AND ESTIMATION SKILL

Helping students improve their ability to estimate and identify the correct location of a number on a number line is a unique and important part of KENS Math. The number line is also an important way to teach children how to calculate relative magnitude. For example, when a child sees the spatial difference between five and eight on a number line, it is easier for the child to understand the difference between eight and five.

From brain studies to the classroom, research strongly supports lessons and interventions to develop a student's number line ability. Support from brain research comes from an evaluation of the functioning ability of the brains of normal adults and patients with brain lesions. Researchers were able to determine that one way in which a number is represented in the brain is through a type of internal number line.<sup>11</sup> Further research has reinforced the view that a child's ability to represent a given

number on a horizontal number line is a critical component in the child's overall number sense ability. For example, multiple studies indicated that a child's ability to estimate the correct placement of a number on a number line was strongly correlated with math achievement at all grade levels.<sup>12,13</sup> Research has also shown that children with mathematical learning



difficulties had greater difficulties accurately placing a number on a number line when compared with typically achieving students.<sup>14</sup> It is also interesting to note that children from preschool through second grade with strong number line skills also had better number recall from word problems.<sup>15</sup>

## GAMES

KENS Math includes a variety of games which target number sense skills. While the games are designed to be motivational and fun, they are also designed to reinforce the core elements of number sense. In one important study, it was shown that math achievement was correlated with the number of board games a child played.<sup>16</sup> This same study also suggests that the design of games is an important element in the effectiveness of the games. Specifically, games like Chutes and Ladders which require players to move their token in a line with even spaces are most effective. Two additional studies, conclude that a linear board game has the ability to improve number line skills, number identification, and arithmetic skills in preschoolers from low and middle income families.<sup>17,18</sup> In KENS Math, the game “Bears and Bridges” is provided to represent this specific type of game. Additional games modeled after successful studies<sup>18</sup> which employ a linear board game are also included.

KENS Math games are introduced in sequence to coincide with the concepts students are learning. Included in KENS Math, for example, are two similar games, “Race to 10” and “Race to 20,” which provide increasing challenges for students at different levels. Card games that reinforce subitizing and strategy games such as “Tag,” “Chase,” “Save the Tigers,” and “Help the Pandas” require students to use a variety of number sense skills. The games are designed for use either in the classroom or to be reproduced and sent home.



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