Pearson

ARTICLE REVIEW:

Computer-Based Programs for Enhancing Mathematical Skills and Spatial Number Representation in Primary-School Children

Rauscher, L., Kohn, J., Käser, T., Mayer, V., Kucian, K., McCaskey, U., . . . von Aster, M. (in press). Evaluation of a computer-based training program for enhancing arithmetic skills and spatial number representation in primary school children. Frontiers in Psychology Computerized Training Programs. http://dx.doi.org/10.3389/fpsyg.2016.00913

The evaluation conducted by the authors Rascher et al. (in press) found that Calcularis can be used effectively to support numerical development and to enhance subtraction and spatial number representation skills based on individual levels of skills. Though evaluations of other computerized training programs revealed good effects for arithmetic performance or spatial number representation, Calcularis demonstrated good effects for both. Questionnaire responses from students and parents indicated that Calcularis was easy and enjoyable to use and little-to-no instructional assistance was needed. Though the study indicates that Calcularis accommodates individual and developmental differences in mathematical abilities training, the authors suggest that future research examine the effect of individual differences, in areas other than math ability (cognitive, behavioral, and motivational) might have on the effectiveness of computerized mathematical training programs.

A study by Rauscher et al. (2016, in press) endeavors to evaluate an adaptive computer training program, Calcularis, constructed within the parameters of theoretical and neuro-cognitive models of number processing and numerical development.

An initial step in their article was to identify several programs which have evidenced-based support. The following programs have shown

- "Rechenspiele mit Elfe und Mathis I" (Lenhard & Lenhard, 2010) is a math-training program, adapted to reflect the German national educational standards for students in grades 1–3. The program consists of five components (quantities, numbers, geometry, word problems, and arithmetic). Research on this program revealed that it positively affected the children's mathematics achievement in a standardized test when compared to a control group that attended a regular math class. A limitation of the program is that it does not follow an instructional hierarchy, which impedes adaptability.
- The "Number Race" program (Wilson et al., 2006) is designed to train numerical comparisons and enhance quantity representation. A small sample of children, ages 7–9 years, with mathematical learning difficulties used the program. The results demonstrated significant improvements in basic numerical cognition, but the effects did not generalize to counting or arithmetic.

continued

- Another study (Rasanen, Saminen, & Wilson et al., 2009) compared "Number Race" to Graphogame-Math (Mönkkönen et al., in preparation). Number Race is used to train children to match verbal labels to visual patterns and number symbols. Using a group of kindergarten students, results of both programs showed improved skills in number comparison, but not in other number skill areas (verbal counting, number comparison, object counting, and arithmetic).
- Finally, the authors reviewed a study that Kucian et al. (2011) conducted on "Rescue Calcularis," an earlier version of the training program examined in this review. The study found that children's understanding of spatial representation of numbers, improved number line conceptualization improved, and brain imaging consistent with the development of numerical task related skills in students with *developmental dyscalculia* (DD).

In their review of these studies, the authors identified a specific need to expand the scope and utility of current interventions. The challenge is to find an intervention that can address multiple mathematical functions and modules, help students develop skills that can be generalized across tasks, and accommodate students on their individual level of skill development.

Study Design and Results

The current study examined the Calcularis program, a more developed and expanded version of "Rescue Calcularis," to determine its efficacy. A Calcularis training group was compared with an untrained control group and a group that used a computerized spelling program.

The study included 138 students (ages 7 to 11 years). The hypothesis was that the Calcularis group would demonstrate increased computation skills (addition, subtraction) and improved spatial number representation when compared to the other two groups.

The study employed a pre/post vs. group ANOVA to determine between- and within-group performance differences as measured with arithmetical tasks and assessments and a number line task. The study also included two questionnaires, one for participating students and one for their parents. Unlike other recent studies, this study included students who represent the whole range of math ability. The study also included a comparison group of students trained on a spelling program to account for generalized cognitive skill development. The results from the study provide further insight to training approaches that affect early acquisition of number processing and math skills.

Calcularis group vs. Control group—The experimental group exhibited larger improvements, especially in subtraction and numerical representation. This finding is considered solid support for the training because subtraction is considered a strong indicator for the development of spatial number representation. The results had medium to strong effect sizes. Though there was no difference in addition, this may be due to variability of subjects' math ability. Addition skills are typically better established in a group of students this age.

Calcularis group vs. Spelling training group—Similar results were found in this comparison, except that effect sizes were slightly smaller. This is mostly due to the impact of the spelling training on generalized cognitive abilities necessary for learning, fact retrieval, and problem solving that are developed within the spelling training at similar rates as Calcularis.

Pearson