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ARTICLE REVIEW:

Modeling and Optimizing the Process of Learning Mathematics

Käser, T., Busetto, A. G., Baschera, G. M., Kohn, J., Kucian, K., von Aster, M., & Gross, M. (2012, June). Modeling and optimizing the process of learning mathematics. In International Conference on Intelligent Tutoring Systems (pp. 389–398). Springer Berlin Heidelberg.s

Developmental dyscalculia **(DD) is a specific learning disability that hinders or delays the acquisition of arithmetic skills. Because students with DD often present unique sets of cognitive difficulties, interventions designed to address DD need to be comprehensive, yet flexible enough to address this level of individuation. Käser et al. (2012) created a game-based training program, *Dybuster Calcularis*, which promotes development of the cognitive processes involved in processing numbers and mathematical tasks. The authors' study chronicles the results of studies conducted to evaluate the training and intervention model used with this program.**

The Training Environment

The neuropsychological models Käser et al. cited highlight the challenges expected in addressing deficits in number representation and mathematical abilities. To address individual and developmental differences in the training program, the authors

- structured the curriculum on the basis of the natural hierarchical development in which basic mathematical skills are the building blocks for more advanced mathematical processes;
- applied a highly exact design for numerical stimuli, enhancing the different representations, number of objects with spoken or written and arabic symbols (*** - three- 3). The variety of number representations and interrelationships help students to form the basis of number understanding (von Aster and Shalev, 2007);
- provided training in operations and procedures with numbers. Students with DD have exhibited difficulties in acquiring simple arithmetic procedures and show a deficit in fact retrieval (Ostad, 1999); and
- designed the training program as a fully adaptive learning environment, which provided the ideal level of cognitive stimulation based on student performance level and need.

Dybuster Calcularis training is composed of multiple games configured in a hierarchical structure that parallels math skill acquisition. Games are designed around number ranges and grouped into two areas:

- Number representations and understanding, which introduces the three principles of number understanding: cardinality, ordinality, and relativity; and
- Cognitive operations and procedures with numbers, for training concepts and automation of mathematical operations.

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A control design is programmed in these games to address the challenges each student experiences. Specifically, it selects the appropriate task items and guides the hierarchical movement through the game based on a student's responses. This facilitates adaptability, addresses memory and knowledge gaps, focuses the task range or locality, and generally addresses the needs of most students.

Evaluation of Training

The authors included preliminary results from two studies that examined the impact of training on public school students (grades 2–5) who were identified as having problems learning mathematics, as reflected in their below-average performance. Experimental results demonstrated that domain knowledge is well represented and the controller function enables the optimization of the learning process through the individuation of cognitive stimulation. The evaluation also demonstrated that the opportunity to go back to easier tasks resulted in a reduced number of mistakes, increased speed of learning, and a positive practice effect. Results from external measures of mathematical performance corresponded with the progression in the training tasks. Specifically, the treatment group that received training improved on two separate tests of math skills. Their correct responses improved by 20% on a test of applying the AC method (factoring by grouping). Subjects were also assessed on the Heidelberger Rechentest (HRT 1–4; Haffner, Baro, Parzer, & Resch, 2005). The HRT has two sections (addition and subtraction) of tasks ordered by difficulty. Examinees are given 2 minutes to complete as many tasks as possible. After training, students in the treatment group improved their performance by 31%.

Summary

The study provides a description of the underlying neuropsychological models which guided the development of their training environment. Specifically, the authors highlight the challenges their model addresses to assist students with Developmental Dyscalculia in improving their mathematical performance. The evaluation of the training, Calcularis, found that the progression participants exhibited on their training tasks is validated by their improved performance on standardized measures of mathematics performance.