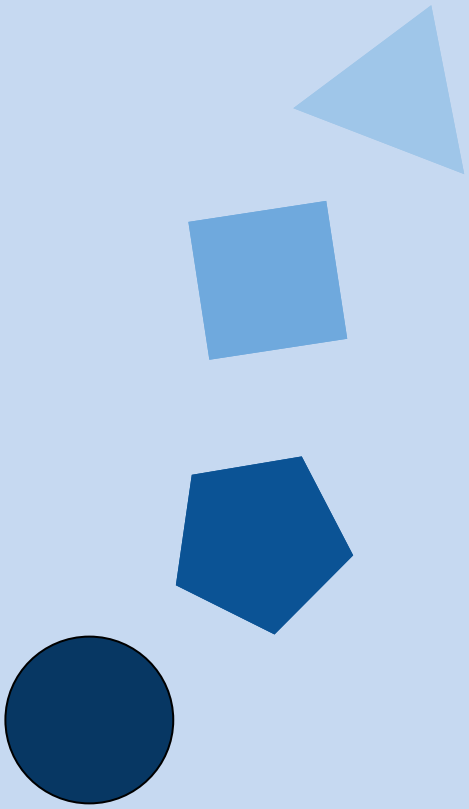
ies NATIONAL CENTER FOR SPECIAL EDUCATION RESEARCH
Institute of Education Sciences



What Have We Funded? A Summary of Mathematics Research

National Center for Special Education Research

FY 2006 - FY 2014

Summarized by Robert Ochsendorf

Background

Students with disabilities (SWD) lag behind their peers without disabilities at all grade levels in mathematics. For example, in the 2013 NAEP mathematics assessment, 45 percent of the Grade 4 students with disabilities who participated in the assessment scored below the basic performance level compared to 14 percent of their peers without disabilities. This gap is more pronounced in Grade 8, with 65 percent of SWD performing below the basic performance level compared to 21 percent of their peers without disabilities (U.S. Department of Education, 2013). Identifying proven instructional practices and strategies that will close these persistent achievement gaps is a challenge facing nearly every school district in the U.S. today.

NCSER has funded 15 projects that focus on mathematics in special education. In the area of early mathematics, an exploratory project led by Paul Morgan at Penn State University analyzed a national representative longitudinal sample of kindergartners to examine predictors of poor math performance over time, examining growth trajectories through Grade 5. This project found that children who displayed persistent mathematics difficulties (MD) in kindergarten (that is, delays evident on a mathematics skills assessment administered in both fall and spring of the kindergarten year) had the lowest growth rates in mathematics skills when compared to the trajectories of children who did not show persistent delays in kindergarten (Morgan, Farkas, & Wu, 2009). This study illustrates children's learning in mathematics reflects their earlier understanding of mathematics. Findings from this study suggest that kindergarten children with persistent delays in mathematics skills are likely candidates for intensive early intervention in preschool and kindergarten to promote proficiency in mathematics skills during their elementary school years.

Development Research

Recent research has shown that many elementary school students with low performance levels in academic areas demonstrate positive growth when provided with intensive intervention (Bryant, et al., 2011; O'Connor, Harty, & Fulmer, 2005). NCSER has funded 8 studies to develop intensive instructional interventions in the area of mathematics in special education. Scott Baker and his colleagues at the University of Oregon have developed a 60-lesson intensive mathematics intervention for students in first grade who are at-risk for mathematics difficulties and disabilities. The intervention, *FUSION*, focuses on whole number concepts including number sense, base 10 and place value, and number operations. While more rigorous studies are needed, initial pilot study results show promise as gain scores of *FUSION* students were significantly larger than those of control peers on a proximal measure of mathematics achievement (Clarke et al., in review). Diane Bryant at the University of Texas has also developed intensive early numeracy interventions for first-grade students with math disabilities. These interventions showed evidence of promise and the investigators are seeking funding for an efficacy study (Bryant, et al., 2011).

Other NCSER funded researchers at the University of Oregon are taking advantage of recent innovations in technology to develop research based individualized interventions to improve

math learning for young students. For example, Mari Strand Cary is developing an iPad-based program, *KinderTEK*, for at-risk kindergarten students which will focus on building conceptual understanding and procedural fluency with whole number concepts. Another example is the work of Hank Fien; he is developing a browser-based, educational video game (*NumberShire)* in which first-grade students learn and apply the mathematical concepts and skills of whole numbers. *NumberShire* will include research-based instructional components that are beneficial to students with or at risk for math disabilities. Both of these interventions target younger students' number sense, quantitative reasoning, and problem solving skills. These development projects directly address the need for earlier and more targeted interventions for students struggling in mathematics.

There are also a number of development projects targeting older math learners at-risk for or with disabilities. Lindy Crawford at Texas Christian University has developed a web-based set of mathematics lessons, *Math Learning Companion* (*MLC*), intended for use with sixth grade students with disabilities. The lessons include accommodations for students (e.g., read aloud features), embedded diagnostic assessments to monitor student progress, and customizable sets of lessons for individual students. This program can adjust to deliver content at a lower level if it is determined that a student needs remediation (that is, cannot perform at grade level). *MLC* students significantly increased their mathematical understanding over the course of the intervention and the intervention was able to tailor to their individual needs, adjusting the amount of time they spent in different sections of the program, skipping certain sections, and using electronic support tools as necessary. This technology-based, individualized intervention is a potential and appropriate model for lower grade-level instruction where students could benefit from developing automaticity and fluency with math facts.

Ben Clarke at the University of Oregon and his colleagues are developing a 100-lesson algebra readiness intervention focusing on conceptual understanding and procedural fluency with rational numbers (i.e., fractions) and equivalent representations for students at risk for math learning difficulties and disabilities. Diane Bryant at the University of Texas is developing *Algebra-readiness Intervention Modules*, focusing on mathematics concepts and skills that are important for success in algebra. These modules will be developed for use in Grade 6 and Grade 7 and will focus on rational numbers, ratio and proportional relationships, expressions and equations, and graphing. Improving outcomes in these areas is critical because recent research has shown that understanding of rational numbers is strongly related to later success in algebra and later mathematics courses (Siegler, et al., 2012).

Efficacy Studies

NCSER has only funded a few efficacy studies in the area of math interventions for SWDs. Brian Bottge at the University of Kentucky has evaluated the effect of *Enhanced Anchored Instruction* (*EAI*), a pedagogical approach that allows middle school students additional opportunities to practice their skills as they solve new but analogous math problems in applied and challenging contexts (e.g., how to build a skateboard ramp—requiring extensive understanding of measurement and fractions). Results from this efficacy study show that *EAI* students in the treatment group improved their performance on math skills contained in several

of the new mathematics standards as compared to students in the control group who did not receive the intervention. Effect sizes were especially large for students identified with MD when the special education teacher actively participated in the instructional activities in collaboration with the math teacher (Bottge & Cho, 2013). Bottge's research suggests that teachers' use of interactive technology tools combined with engaging hands-on applications can positively change what students with MD achieve in mathematics, particularly in problem solving (Bottge, et al., in press). In addition, Marjorie Montague at the University of Miami tested the efficacy of *Solve It!*, an intervention designed to teach students with learning disabilities how to understand, analyze, solve, and evaluate mathematical problems by developing and utilizing the processes and strategies that effective problem solvers use (such as, hypothesizing about solutions, estimating the outcome or answer, and checking solutions). Results showed that students across ability levels who received *Solve It!* instruction reported using significantly more strategies than students in the comparison group (Krawec, et al., 2013).

More recently, NCSER has funded researchers such as Ben Clarke at the University of Oregon to test the efficacy of a fully-developed mathematics intervention for kindergarteners. This intervention, *ROOTS*, was developed to improve the mathematics skills of students with or at risk for MD. The study will evaluate two versions of the *ROOTS* intervention to investigate their effects as well as the relationship between group size and student outcomes. The first intervention is a high-intensity version with two students in each intervention group; the second intervention is considered to be a low-intensity version with five students in each intervention group. Given that many schools and districts implementing intensive interventions often lack empirical evidence to support decision-making regarding their allocation of resources to such interventions, findings from this study regarding the intensity level necessary to impact student outcomes may be beneficial to the field.

Low Incidence Disabilities

NCSER has funded four projects in the area of mathematics for students with low-incidence disabilities. Diane Browder at the University of North Carolina-Charlotte has received two awards to develop mathematics and science instructional interventions for students with moderate and severe intellectual disabilities (Jimenez, et al., 2012). Dr. Browder's most recent grant is focused on developing a math problem-solving intervention for middle-school students. This research has shown that students with moderate and severe intellectual disabilities are capable of learning grade-level content in math and science, challenging long held assumptions about the academic potential of these populations (Courtade, et al., 2012). Lois Frankel at the Educational Testing Service and her colleagues are developing *ClearSpeak*; a more accessible mathematical language that can be integrated with existing screen-reader software currently being used by the visually impaired community. This program is developed to improve the accessibility of math expressions (e.g., 1/2, 2/4 ÷ 1/4, etc…), which are currently not translated very well by existing screen-reader software programs. Also conducting research in the area of accessibility for students with visual impairments, Carole Beal at the University of Arizona is developing *Animal Suite-VI*; this intervention will include a set of 14 web-delivered, accessible instructional modules covering computation, fractions, and variables and expressions for

students with visual impairments in middle school and high school. Each module will include word problems and instructional scaffolding accessible via self-voicing software, accompanied by braille and tactile graphics.

Assessment

In addition to these instructional intervention development projects, NCSER is currently supporting the development of measurement tools in elementary and middle-school mathematics. More reliable screening for MDs can provide practitioners with better information as to who needs and would benefit from targeted intervention and remediation in the early elementary grades. Lynn Fuchs at Vanderbilt University is developing a dynamic assessment intended to function as a more effective screening tool for students at risk of poor mathematics performance in first grade. Dynamic assessments are intended to measure a student's capacity to learn rather than what the student presently knows. This measurement study has demonstrated that dynamic assessment can be more robust than static tests as a predictor of word problem solving development in mathematics for first graders (Seethaler, et al., 2012).

Kavita Seeratan at SRI International is developing both a formative and summative assessment system to assess and improve learning for elementary and middle school students with learning disabilities in mathematics. The focus is on conceptual understanding of pre-algebra constructs, such as number sense and operations for whole numbers and fractions. In addition, Gerald Tindal at the University of Oregon is developing and validating a set of online middle-school mathematics progress monitoring measures, including measures of numbers and operations, geometry, algebraic relations, measurement, and analysis.

National Research & Development Center

Finally, NCSER has funded a national research and development (R&D) center in the area of mathematics, The Center for Improving the Learning of Fractions. This R&D center, led by Nancy Jordan at the University of Delaware was funded to increase knowledge of how children acquire and fail to acquire an understanding of rational numbers (i.e., fractions) and how best to teach children with math difficulties to understand and operate fluently with rational numbers. The center is conducting exploratory research including longitudinal studies to examine the cognitive processes, such as working memory and inhibition, which impede understanding and operating with fractions. Findings from the center studies have been used to inform the design and testing of an intervention package intended to improve fraction skills in students with math difficulties. As part of the center's research, analyses of two large and longitudinal data sets, one from the U.S. and one from the United Kingdom, indicated that fifth graders' knowledge of fractions uniquely predicted the same students' knowledge of algebra and overall mathematics achievement in high school 5-6 years later; even after statistically controlling for other mathematical knowledge, verbal and non-verbal IQ, reading comprehension, working memory, and family income and education (Siegler, et al., 2012). Analyses using the center's own longitudinal dataset have shown that the ability of a student to estimate the placement of whole numbers on a number line was the most important predictor of fractions knowledge (both

conceptual and procedural) (Jordan, et al., 2013). Also as a part of the center's intervention research, a series of three randomized controlled trials were conducted to assess the efficacy of the intervention, *Fraction Face Off!,* an intensive intervention program which focuses heavily on promoting the understanding of fraction magnitudes. In each study, for each outcome, results favored students that were randomly assigned to the *Fraction Face Off!* treatment conditions as compared to those students that were randomly assigned to the business-as-usual control groups (Fuchs, et al., 2014; Fuchs, et al., in preparation;). As the work of the center progresses over the next several years, a more complete picture of mathematical learning in grades 3-8 will be provided as a result of ongoing longitudinal data collection. The NCSER funded center researchers will provide an even deeper understanding of both the cognitive and school related academic factors that are predictive of later math success as well as evidence of interventions that work for students at risk for or with disabilities.

Future Directions

NCSER funded researchers are leading efforts to improve the quality of mathematics interventions for students at-risk for and with disabilities as well as the assessments of these students to ensure they can be successful both in and out of school. Several NCSER funded researchers have made important contributions to our understanding of the importance of foundational early mathematics skills necessary for future math success. There remains a great deal to be learned about the best ways in which to support these students. The special education field still lacks a full and detailed understanding of the characteristics of effective early mathematics programs (that is, those in prekindergarten and kindergarten). A renewed emphasis on prevention with a focus on quality instruction and instructional materials, as well as effective teaching strategies and professional development, could go a long way in addressing the mathematics difficulties SWDs face. Despite considerable development efforts in mathematics education in general, there is still a lack of understanding regarding what kinds of interventions, programs, and policies are best suited to remediate deficits for students with or at risk for MD. In addition, more rigorous research is needed to produce high quality screening measures and other assessments to ensure that all students are appropriately assessed and those in need are provided opportunities to receive high-quality intensive interventions.

Mathematics and Science in Special Education
http://ies.ed.gov/funding/ncser_rfas/ncser_mathsci.asp
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