OSEP Research Institutes: Bridging Research and Practice

IDEAs that Work
U.S. Office of Special Education Programs

In this column, *Bridging Research and Practice,* three of the federally funded special education research institutes report to you, the practitioner, on their progress in areas that will be particularly helpful to you in working with your students. The U.S. Office of Special Education Programs (OSEP) has funded these three research institutes to study specific curricular and instructional interventions that will accelerate the learning of students with disabilities in curricular areas:

Center on Accelerating Student Learning (CASL) focuses on accelerating reading, math, and writing development in Grades K-3. The Directors of CASL are Lynn and Doug Fuchs of Vanderbilt University. Principal Investigators include Joanna Williams at Columbia University and Steve Graham and Karen Harris at Vanderbilt University.

Research Institute to Accelerate Content Learning Through High Support for Students With Disabilities in Grades 4-8 (REACH) is examining interventions that reflect high expectations, content, and support for students. The Director of REACH is Catherine Cobb Morocco at Education Development Center in Newton, MA. Research partners include the University of Michigan (Annemarie Palincsar and Shirley Magnusson), the University of Delaware (Ralph Ferretti, Charles MacArthur, and Cynthia Okolo), and the University of Puget Sound (John Woodward).

The Institute for Academic Access (IAA) is conducting research to develop instructional methods and materials to provide students with authentic access to the high school general curriculum. The Institute Directors are Don Deshler and Jean Schumaker of the University of Kansas, Lawrence. Research partners include the University of Oregon and school districts in Kansas, California, Washington, and Oregon.

This issue features the CASL.

Responsiveness to Intervention: Preventing and Identifying Mathematics Disability

Lynn S. Fuchs, Donald. L. Compton, Douglas Fuchs, Kimberly Paulsen, Joan Bryant, and Carol L. Hamlett

The Center on Accelerating Student Learning (CASL) is a collaborative partnership among faculty at Vanderbilt University (Lynn and Doug Fuchs, Steve Graham, and Karen Harris), Columbia University (Joanna Williams). CASL's goal is to identify instructional practices that accelerate the learning of children with disabilities in kindergarten through grade 3. This includes the development of effective, multicomponent instructional interventions in reading, writing, and math, which focus on basic skills and higher-order learning and promote fluency, transfer, and maintenance. CASL has also examined rates of responsiveness to those interventions, while exploring methods for operationalizing responsiveness.

In this column, we describe work on intervention responsiveness in mathematics. Although this work had its origins within CASL, the research and development we describe in this column was conducted under the auspices of the National Research Center on Learning Disabilities, sponsored by the U.S. Department of Education?s Office of Special Education Programs (OSEP). This work focuses on response to intervention (RTI) as a means of simultaneously preventing and identifying disability in first grade. With RTI, children are identified at the beginning of first grade as at risk for poor learning outcomes at the end of the year. These at-risk children receive intervention. For students who respond well to the intervention, we assume that their initial difficulty that was manifested at the beginning of the year, stemmed from inadequate instruction or insufficient background experience, and that RTI has served to prevent continued academic difficulties. By contrast, for students who fail to respond to the intervention, RTI has eliminated poor instructional quality or prior background as a viable explanation for poor academic performance at the beginning of the year; instead, the RTI assessment has provided evidence of a disability.

As an approach for reading disability identification, RTI has undergone some study, with some supportive findings (e.g., Speece & Case, 2001; Vellutino et al.,1996). In mathematics, however, less research has been conducted, and the focus of those studies has been relatively limited (e.g., Ardoin, Witt, Connell, & Koenig, 2001; VanDerHeyden & Witt, in press). With this in mind, we set out to develop and test a comprehensive version of RTI. Our goals were to prevent and to identify math disability (MD) early, when difficulties begin to emerge, in first grade.

Toward those ends, we assessed the mathematics performance of children in 41 first-grade classrooms in 10 schools at the beginning of the school year. We identified children at risk for the development of mathematics difficulty and randomly assigned them to tutoring and control conditions. Tutoring occurred 3 times weekly for 16 weeks. We then assessed math outcomes for the initially at-risk and not-at-risk children. We used these data to (a) assess the preventative effects of tutoring and (b) estimate the prevalence and severity of MD with and without tutoring and as a function of identification procedure.

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Table 1. First-Grade Math Tutoring Topics and Number of Sessions

Topic	Number of Sessions Covered
1. Identifying and writing numbers to 99	1-3, depending on mastery
2. Identifying more or less with objects	1-3, depending on mastery
3. Sequencing numbers	3
4. Using <, >, = symbols	1-3, depending on mastery
5. Skip counting by 10s, 5s, 2s	1-3, depending on mastery
6. Introduction to place value	3: cannot skip any
7. Identifying operations	1-3, depending on mastery
8. Place value 0-50	1-3, depending on mastery
9. Writing number sentences	1 and 2 must be completed; 3 depends on mastery at day 2
10. Place value 0-99	3
11. Addition facts to sums of 18	1-4 must be completed; 5-6 depends on mastery at previous day
12. Subtraction facts to minuends of 18	1-4 must be completed; 5-6 depends on mastery at a previous day
13. Review of addition and subtraction facts	1-3, depending on mastery
14. Missing addends	1-3, depending on mastery
15. Place value	1-3, depending on mastery
16. Two-digit addition with no regrouping	1-3 must be completed; 4-6 depends on mastery at previous day
17. Two-digit subtraction with no regrouping	1-3 must be completed; 4-6 depends on mastery at previous day

How We Identified Risk at the Beginning of First Grade

We monitored the progress of all students in each of the 41 classes using weekly curriculum-based measurement (CBM; Fuchs, Fuchs, & Hamlett, 1990). With CBM, a 25-item test, sampling the universe of computation skills addressed in first grade, is administered each week. Each weekly test samples the same problem types in the same proportions, but the problems are displayed in random order. Students have 2 minutes to write answers. To identify risk for poor end-of-year math outcome, we averaged CBM scores across weeks 3 to 5 (i.e., in September), using a cut-point of less than 11 correct problems to designate at-risk students.

How We Structured Intervention

Intervention comprised small group tutoring and individualized computer practice, for a total of 40 minutes per session. Tutoring occurred in groups of 2 to 3 students, 3 times per week for 16 weeks, each time for 30 minutes. At the end of each session, students worked individually for an additional 10 minutes on software designed to promote automatic retrieval of math facts.

Small group tutoring (Paulsen & Fuchs, 2003) was based on the concrete-representational-abstract method for teaching math (Butler, Miller, Crehan, Babbitt, & Pierce, 2003; Cass, Cates, Smith, & Jackson, 2003; Mercer, Jordan, & Miller, 1996). This model relies on concrete objects to promote conceptual learning. Lessons followed a sequence of 17 scripted topics, and each topic included activities that relied on worksheets and manipulatives (e.g., base-10 blocks for place value instruction). The sequence of topics is shown in Table 1. Thirteen topics were each addressed with three lessons; the remaining four topics were each addressed with six lessons. Mastery of the topic was assessed each day. If every student in the group achieved mastery prior to the last day on the topic, the group moved to the next topic. (A few topics required completion of all days.) For mastery assessment, students completed worksheets independently during the session; percentage of correct answers determined mastery (for most topics, 90% accuracy). After the last day on a topic, the group progressed to the next topic regardless of mastery status. On the first day of each topic, students completed a cumulative review worksheet covering previous topics. Throughout each tutoring session, tutors awarded points to students for appropriate behavior. As point sheets were completed, students traded points for prizes.

During the final 10 minutes of each intervention session, students used software, *Math FLASH* (Fuchs, Hamlett, & Powell, 2003), designed to promote automatic retrieval of math facts. With *FLASH*, the computer briefly shows a math fact. After the fact disappears, the student types the fact into the computer. When the student types the fact correctly, (a) the student's typed fact remains on the screen, (b) the computer says the fact aloud, and (c) the computer "applauds" and awards points. Every five points translates into a "prize" (e.g., image of a puppy, candy, sun), which accumulate in a "treasure box" at bottom of the screen. When the student types the fact incorrectly, the student's typed fact disappears, and the computer shows and says the correct fact; then, the student types it correctly. No applause or point is awarded. When a fact is completed, another flashes. The duration of the flash depends on the student's performance during the session (if the student fails several items, the duration increases). At the session's

Classroom Teacher and Tutor Perspectives

Ms. Riggs is a first-grade classroom teacher in the Metropolitan Nashville Public Schools:

> I loved the weekly [CBM] tests. The spiraling it did every week, reinforcing skills they were learning, kept it fresh in their minds. The [CBM] progress reports were a wonderful tool for me. I could identify areas where individual students needed the most help and could zone in and target those areas. Tutoring was also beneficial for the students in my class who received it—they made gains and their grades went up. One of the students went from making Ds to making As in math. They loved tutoring and would fly back from lunch to get their pencils ready. I felt that when my students left my class at the end of the year, they had a really good grasp of math concepts. With the current emphasis on reading, it was helpful to me to have a program that helped me stay focused on math as well.

Shelley Wooten is seeking an M.Ed. in School Counseling at Vanderbilt University and was a tutor in the study:

> Watching the students gain confidence as their math skills increased was the most remarkable aspect of the tutoring program for me. The students really benefited from the small group format and the hands-on activities incorporated into each lesson. The students particularly enjoyed the FLASH computer program. It was a fun way to end each lesson, and the students challenged themselves to exceed their highest score every day. The benefit of this extra practice was evident in their speed and fluency in recalling math facts.

end, the computer shows the number of items correct for the session and the highest level of mastery attained across sessions.

The program targets fact families (e.g., 1 + 2 = 3, 2 + 1 = 3, 3 - 1 = 2, 3 - 2 = 1), beginning with smaller families and becoming more difficult as families are mastered. Facts already classified as mastered reappear periodically for cumulative review. Each student's level of mastery is saved, and the student continues the next session where the previous session left off. In this study, addition and subtraction facts with answers to 9 were included.

What We Found

Intervention Efficacy

Findings supported the efficacy of the intervention on computation, concepts and applications, and story problems (see box, "Classroom Teacher and Tutor Perspectives"), where the improvement of the at-risk tutored students exceeded that of the at-risk control group. Moreover, depending on the measure, the growth of the at-risk tutored students was either comparable or superior to that of their not-at-risk classmates. Results were less strong on automatic retrieval of math facts, where we have redesigned the software to strengthen those effects. Altogether, however, results do support the premise that first-grade intervention can be effective in promoting stronger math outcomes. This suggests the promise for first-grade RTI to reduce mathematics difficulty on key aspects of performance and to serve as a "test" within a RTI framework for identifying MD.

Prevalence and Severity of MD

We also assessed the prevalence and severity of MD at the end of first grade, as it develops with and without prevention and as a function of alternative ways of defining the phenomenon, including RTI options, on a variety of math outcomes. Findings demonstrated that prevention did reduce MD prevalence. Across 16 methods we employed to identify MD, prevention reduced MD by a mean of 35.64%. For example, take one RTI method for designating MD, where students are deemed MD if their final achievement on first-grade concepts and applications falls below the 10th percentile. For this identification procedure, prevalence fell from 9.75% without prevention to 5.14% with prevention. With 53.3 million school-age children (United States, 2004), this translates into approximately 2.5 million fewer children identified as MD. Of course, these reductions reflect MD status just after prevention. As students progress in school, the effects of prevention can be expected to diminish, and without additional support, some "responders" will reemerge as MD. For this reason, we are following this sample through third grade.

Separate from the issue of how prevention affects MD prevalence, results also show how identification procedure affects both MD prevalence and MD severity. Looking across the various methods for designating MD, we formulated three conclusions. First, IQ-achievement discrepancy using commercial achievement tests, where behavior sampling within any given grade level is lean, results in few MD identifications at the end of first grade. However, IQ-achievement discrepancies that rely on achievement measures with thorough grade-level behavior sampling may sensitize detection of MD in first grade. Second, RTI for MD identification is a promising alternative to the traditional IQ-achievement discrepancy approach. Third, within a RTI framework for MD identification, two methods appear promising: final low achievement on first-grade concepts/applications and computation CBM dual discrepancy (where students demonstrate a poor rate of growth and a poor final achievement level).

In Sum

Conclusions must be tempered by the absence of follow-up data to determine how well first-grade math RTI prevents long-term difficulty and forecasts students who will experience serious problems as they progress in school. Pending long-term results, however, we tentatively conclude that intervention, comprising approximately 24 hours of small-group tutoring and 8 hours of computer work, can substantially enhance first-grade students' end-of-year performance on math computation, concepts/application skills, and story problems. Our controlled experimentation also indicates that RTI, which incorporates this intervention, may represent a promising alternative for preventing and identifying MD relatively early in a child's school experience. Identifying nonresponders for special education, in this way by the end of first grade, would permit highly skilled special educators to intervene in math more intensively and earlier than has occurred to date, with the goal of enhancing outcomes for students with MD.

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