Title: Inclusive Fraction Instruction versus Specialized Fraction Intervention for Very Low-Performing Students

Authors and Affiliations:
Robin F. Schumacher, Vanderbilt University
Lynn S. Fuchs, Vanderbilt University
Douglas Fuchs, Vanderbilt University
Donald L. Compton, Vanderbilt University
Joseph Wehby, Vanderbilt University
Russell Gersten, Instructional Research Group
Nancy C. Jordan, University of Delaware
Abstract Body

**Problem:** In the past 25 years, the dominant reform related to students with learning disabilities (LD) is inclusion, which features Universal Design for Learning (Center for Applied Special Technology, 2011) and other accommodations to provide students with access to high academic standards in regular classrooms, along with collaboration between general and special educators to support these students’ learning. Despite inclusive reforms, the achievement of students with LD has stagnated at very low levels (e.g., Judge & Watson, 201; Schiller et al., 2008; U.S. DOE, 2013; Wagner, Marder et al., 2003; Wagner, Newman et al., 2003). The magnitude and persistence of these academic deficits raise important questions about the nature and effectiveness of the value of relying heavily on core classroom instruction, with accommodations, to meet these students’ academic needs.

Yet as the U.S. curriculum shifts to the more rigorous CCSS, instructional recommendations for students with LD continue to focus dominantly on inclusionary practices (e.g., McLaughlin, 2012; Common Core Web site). The major alternative for addressing the academic needs of students with LD is specialized intervention: programs that rely on carefully designed, complex instructional routines, based on principles of explicit instruction and state-of-the-art understanding of the domain (e.g., Fuchs & Fuchs, 2009). Although specialized intervention can dramatically reduce achievement gaps (e.g., O’Connor & Fuchs, 2013), it plays a decidedly secondary role to the inclusionary ideal of Universal Design for Learning and classroom accommodations. So it is unfortunate that rigorous studies have not been conducted to contrast the efficacy of inclusive instruction vs. specialized intervention for very low performing students on academic outcomes. Such studies are needed to guide practitioners about the type of service delivery required to help these learners profit from the CCSS reform.

**Purpose:** To gain insight into how the CCSS reform may affect the learning of very low performers as a function of these 2 service delivery models, we analyzed data from 3 RCTs, conducted in 3 consecutive years in a large, urban school district. The 3 years spanned the time frame during which the district moved toward CCSS implementation. We looked at the subset of 4th-grade students who began the RCTs with mathematics achievement scores at or below the 10th percentile. These very low performers had been randomly assigned at the individual level to inclusive fraction instruction vs. specialized fraction intervention, and students in both conditions received a similar amount of math instruction. We examined whether fraction learning differed as a function of service delivery option and considered how these groups’ achievement gaps, relative to the low-risk classmates, changed during the transition to CCSS.

**Intervention:** The specialized intervention used in the 3 RCTs was developed to provide explicit instruction, routed in state-of-the-art thinking about fractions. Competence with fractions is considered foundational for learning algebra, for success with more advanced mathematics, and for competing successfully in the American workforce (NMAP, 2008). Yet, half of middle and high school students in the U.S. are still not proficient with the ideas and procedures taught about fractions in the elementary grades (e.g., NCTM, 2007; NMAP). The NMAP thus recommended that high priority be assigned to improving fraction performance, an emphasis reflected in CCSS.

In the early stages of fraction knowledge (usually 4th grade), 2 ways of understanding fractions are critical (e.g., NMAP, 2008). The first is part-whole interpretation, with which a fraction is understood as a part of one entire object or a subset of a group of objects. Such understanding is often evident as early as preschool (e.g., Mix et al., 1999), based on children’s
experiences with sharing. In U.S. schools, symbolic fraction notation, introduced in 1st grade, is taught via area models that underpin part-whole understanding. By 4th grade, the dominant emphasis on part-whole interpretation persists. In the RCTs analyzed in this report, the school’s inclusive program emphasized part-whole interpretation.

The second type of understanding, the measurement interpretation of fractions, reflects cardinal size (Hecht et al., 2003). Often represented with number lines (e.g., Siegler et al., 2011), this type of interpretation is less intuitive and is thought to depend on formal instruction. Yet, the measurement interpretation of fractions has been assigned a subordinate role to part-whole interpretation in U.S. classrooms, even though NMAP (2008) viewed the measurement interpretation of fractions as the more important mechanism behind fraction learning. An emphasis on the measurement interpretation therefore represents the more state-of-the-art instructional approach for promoting understanding of fractions. Accordingly, the specialized intervention condition focused more on the measurement interpretation. The specialized intervention program occurred 3 times per week for 12 weeks for 30 minutes per session.

**Participants:** In the RCTs from which data for the present analysis were derived, we defined risk as performance <35th percentile at start of 4th grade on a broad-based calculations measure (Wide Range Achievement Test–4 [WRAT]; Wilkinson & Robertson, 2006). To ensure strong representation across the range of scores below the 35th percentile, we sampled half the at-risk students from below the 15th percentile; the other half from between the 15th-34th percentiles. We administered the 2-subtest Wechsler Abbreviated Scales of Intelligence (WASI; Wechsler, 1999) to all students who met the risk criterion (because the studies were not about intellectual disability, we excluded children with T-scores <9th percentile on both subtests). We sampled 3-9 at-risk students per class, stratifying by more vs. less severe risk in each class. The sample comprised 268 students from 53 classes in 13 schools in Year 1; 243 students from 49 classes in 14 schools in Year 2; and 197 students from 45 classes in 14 schools in Year 3. We randomly assigned students at the individual level, stratifying by classroom and risk severity, to 2 conditions in Year 1: the school’s inclusive program versus the study’s specialized intervention. In Years 2 and 3, students were randomly assigned to 3 conditions: inclusion or one of two variants of the specialized intervention.

Because effects on study outcomes included in the present analysis were comparable for the 2 intervention variants in Years 2 and 3, we combined the 2 intervention conditions for the present analysis. To focus on the subset of at-risk students representative of the achievement level of students with LD, we limited the sample for the present analysis to students who began 4th grade on the mathematics screener at or below the 10th percentile. To represent response to inclusive fraction instruction of such low performers, we restricted the sample to students who received instruction without special education pullout math services.

After random assignment, 1-3 students (depending on year) moved to schools outside the study’s reach. Students who moved did not differ statistically from remaining students on any demographic or pretest variable and did not differ significantly on any demographic or pretest variable as a function of condition. We omitted children who moved, leaving 42 inclusion and 39 intervention students in Year 1; 23 inclusion and 44 intervention students in Year 2; and 19 inclusion and 38 intervention students in Year 3. At-risk students in the 2 service delivery conditions were comparable on WRAT-Arithmetic and WASI IQ.

To index posttreatment achievement gaps, we compared students’ post-intervention performance on group-administered fraction measures against performance of low-risk
classmates. We obtained the sample of low-risk classmates by randomly sampling students who began 4th grade >33rd percentile on the screening measure. Sampling was conducted to represent each of the participating classes in similar proportion to at-risk students in the larger RCTs. In Years 1, 2, and 3, respectively, this low-risk classmate sample included 282, 265, and 320 children. Depending on year, 10–19 students moved during the study; those students did not differ from remaining students on pretest measures.

**Research Design:** Synthesis over 3 independent randomized control trials, each with individual students, stratified by classroom and severity of risk status, randomly assigned to conditions.

**Data Collection:** To provide an index of post-intervention achievement gaps, we focused on 3 group-administered measures. To provide a measure on which the specialized intervention condition allocated more attention than the inclusion condition (the measurement interpretation of fractions), we included Comparing Fraction (Schumacher et al., 2012). It assesses magnitude understanding with 15 items, each of which shows 2 fractions. Students write >, <, or = between the fractions. The maximum score is 15. Alpha on this sample = .84.

To provide a measure on which the inclusion condition allocated more attention than the intervention condition (i.e., fraction procedures), we administered 2 subtests of the Fraction Battery-2012-revised (Schumacher et al., 2012). Fraction Addition includes 5 addition problems with like denominators and 7 addition problems with unlike denominators. Fraction Subtraction includes 6 subtraction problems with like denominators and 6 with unlike denominators. Items are scored as 1 point for finding the correct numerical answer; 2 points if the item is reduced 1 time; or 3 points if the item is reduced twice. We used the total score across these tests, which correlated .83. The maximum score across the tests is 41. Alpha on this sample = .91.

To index generalized learning about fractions, which was comparably distal for both conditions and addressed the measurement interpretation of fractions and the part-whole interpretation of fraction with equal emphasis, we administered 19 released items from 1990-2009 NAEP: easy, medium, or hard fraction items from the 4th-grade assessment or easy from the 8th-grade assessment. The maximum score is 25. Alpha on this sample = .83.

**Findings:** Posttest scores favored specialized intervention students over inclusive instruction students on each measure in each year. In Year 1, $F(1,79) = 42.34, p < .001$ on Comparing Fractions (effect size [ES; difference in means divided by pooled SD] = 1.67); $F(1,79) = 129.38, p < .001$ on Calculations (ES = 2.54); and $F(1,79) = 10.03, p < .001$ on NAEP (ES = 1.46). In Year 2, $F(1,65) = 9.38, p = .003$ on Comparing Fractions (ES = 0.80); $F(1,65) = 40.67, p < .001$ on Calculations (ES = 1.72); and $F(1,65) = 10.25, p = .002$ on NAEP (ES = 0.83). In Year 3, $F(1,55) = 16.87, p < .001$ on Comparing Fractions (ES = 1.17); $F(1,55) = 9.45, p = .003$ on Calculations (ES = 0.87); and $F(1,55) = 3.40, p < .001$ on NAEP (ES = 1.03). Across measures, the mean ES for Years 1, 2, and 3, respectively, were 1.89, 1.68, and 1.54. Across years, the means ES for Comparing Fractions, Calculations, and NAEP, respectively, were 1.21, 1.71, and 1.11. (We did not employ nested analyses to control for dependency due to students’ membership in classes because the ICCs (estimated with SPSS MIXED, version 20) were < .02. Also, students had been randomly assigned to study conditions at the individual level and, with 203 students drawn from 147 classrooms, there were few students per classroom.)

Low-risk classmates improved posttest fraction performance on each measure and year, reflecting increasing depth and challenge of the fraction curriculum as CCSS was implemented.
On posttest Comparing Fractions, performance across the 3 RCTs increased from 7.21 (SD = 3.27) in Year 1, to 9.97 (SD = 3.60) in Year 2, and to 11.23 (SD = 3.95) in Year 3. On posttest Calculations, scores also increased: from 10.18 (SD = 4.84) in Year 1, to 14.43 (SD = 7.78) in Year 2, and to 19.21 (SD = 9.25) in Year 3. On posttest NAEP, performance increased from 14.69 (SD = 3.50) in Year 1, to 16.48 (SD = 4.04) in Year 2, and to 18.95 (SD = 3.81) in Year 3.

Conclusions: In each RCT, conducted in subsequent years, the posttest fraction performance of students who received specialized fraction intervention exceeded that of students who received inclusive fraction instruction. The between-group differences were robust, with large ESs obtained across measures. We also examined the posttest achievement gaps of very low-performing students as the depth and degree of challenge of classroom fraction instruction increased over the 3 RCTs. A clear indicator of the inclusive fraction program’s increasing depth and challenge was the low-risk classmates’ dramatic gains over the 3 years. This further presses the resources of inclusive programs to address very lower performers’ needs more appropriately, even as the enhanced outcomes of classmates creates a more ambitious frame of reference for judging the achievement levels required of very-low performers. Otherwise, achievement gaps widen. This is exactly what happened. Over the same 3-year timeframe, in response to the same inclusive instruction low-risk classmates received, very low performers demonstrated stronger rates of learning from Year 1 to Year 2, an increase in ES of approximately 1/3 of a SD. But this rate of improvement from Year 1 to 2 failed to keep pace with the rate of improved learning for low-risk classmates. More disturbingly, as CCSS implementation increased from Year 2 to Year 3, the rate of learning of very low-performers came to a halt, as the achievement of their low-risk classmates continued to grow. So the achievement gaps of very low performers served by inclusive instruction increased from a posttest deficit of 0.64 SDs in Year 1 to 1.10 in Year 2 to 1.47 SDs in Year 3. This suggests strong added value for specialized intervention over inclusive instruction – at least for fractions, which is often deemed one of the most critical areas of elementary school mathematics (Siegler et al., 2012). Results suggest the importance of specialized intervention for very low performers.

Prospectively designed RCTs are however needed to contrast the effects of inclusive instruction against specialized intervention for the kind of very low performers who were the focus of this analysis. These studies should specifically target students with LD and focus on a variety of curricular domains. Such prospective studies should also provide detailed classroom observations of inclusive instruction. Further, studies should provide information about financial and logistical conditions that support specialized intervention. Such RCTs might feature a specialized intervention that reflects state-of-the-art understanding of the domain, as in the present analysis and as expected of validated specialized interventions. Other RCTs might control for state-of-the-art understanding of the domain across the inclusive instruction and specialized intervention conditions. In terms of inclusive instruction, such RCTs might feature typical practices to be broadly generalizable, as in the present analysis, or state-of-the-art Universal Design for Learning, accommodations, and co-teaching practices to reflect the ideal.
Appendix A. References


