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Impact of Enhanced Anchored Instruction in Inclusive Math Classrooms

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Abstract

The Common Core State Standards for Mathematics will place more pressure on special education and math teachers to raise the skill levels of all students, especially those with disabilities in math (MD). The purpose of this study was to assess the effects of enhanced anchored instruction (EAI) on students with and without MD in co-taught general education classrooms. Results showed that students in the EAI condition improved their performance on math skills contained in several of the standards. Effect sizes were especially large for students with MD when the special education teacher more actively participated in the instructional activities with the math teacher. Classroom observations provided examples of how teachers can work together to benefit students in inclusive math settings.

Results of the National Assessment of Educational Progress (NAEP; National Center for Education Statistics, 2011), meta-analyses of math research (Baker, Gersten, & Lee, 2002), and intervention studies (VanDerHeyden, McLaughlin, Algina, & Snyder, 2012) have shown the difficulty in improving the math skills of middle school students with disabilities in math (MD). One reason for the lack of progress can simply be due to the limited number of researchers who investigate academic interventions for secondary school students with MD. For example, only 15.9% of the articles in special education journals between 1988 and 2006 targeted academics (Mastropieri et al., 2009), with reading studies outnumbering math studies five to one (Gersten, Clarke, & Mazzocco, 2007). Moreover, meta-analyses have typically included studies with elementary-age students only or sorted publications by intervention type without regard to age (Gersten et al., 2009).

Another contributing factor may be the lack of consensus over what constitutes quality math problems for students with MD. By far the most common way of teaching and assessing problem solving in schools involves encoding a problem in text (i.e., word problems). Besides this having little or no connection with everyday life (Lave, 1993), many students who have comorbid learning difficulties in math and reading must struggle to comprehend the problem description (Dunlap, 1982; Vukovic, 2012). To improve accessibility, special educators have developed strategies, such as cognitive strategy instruction (Coughlin & Montague, 2011) and schema-based instruction (Jitendra, DiPipi, & Perron-Jones, 2002), that guide students through a series of steps to help them identify important parts of the problem, formulate a tentative solution, and evaluate their answer. However,

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procedures for helping students decipher problem contexts can become so routinized that students may sometimes miss the meaning and relevance of the targeted math concept (Brown, Collins, & Duguid, 1989).

In contrast to the word problem approach, medicine and industry typically form teams of problem solvers who work together to find plausible solutions to the types of problems found in workplace contexts (Gijbels, Dochy, Van den Bossche, & Segers, 2005). Often referred to as *problem-based learning* (PBL), the method is designed to activate prior knowledge, foster habits of problem exploration, and help problem solvers remember and generalize their strategies. PBL strategies can include explicit teaching at certain key points during the problem-solving process (Hmelo-Silver, Duncan, & Chinn, 2007). Despite its popularity, relatively few controlled studies have tested the effects of PBL in K–12 settings. One exception is a randomized experiment conducted with students with MD that showed positive results of PBL over the traditional lecture discussion method (Wirkala & Kuhn, 2011).

Evolving Enhanced Anchored Instruction

For more than a decade, our research teams have developed and tested a range of problem-solving strategies for secondary school students with low academic skills. Our work has been driven in part by what we consider the negative properties of word problems (e.g., artificial contexts, accessibility issues) on the one hand and the potential of PBL methods (e.g., motivating, realistic problems) on the other. Sharing the opinions of scholars like Schoenfeld (1989) and Bruner (1960), we judge problem quality in large part by the effect on learners, that is, by the ability of the problem to sustain genuine interest, strengthen procedural skills, and deepen conceptual understanding. Our first attempts at designing problems for students with MD were much like the problem-solving anchors developed at Vanderbilt University in the late 1990s (Cognition and Technology Group at Vanderbilt, 1997), albeit less complex and lower in technical quality. Each overarching anchor consisted of a single video in which students searched scenes to identify relevant information leading to a reasonable solution. Similar to PBL, teachers assisted students by asking probing questions and providing instructional support as needed.

Results from a series of studies with early versions of anchored instruction (Bottge, Heinrichs, Chan, & Serlin, 2001) showed important advantages of delivering problems by video compared to text. Teachers and classroom observers reported that the videos immersed students in the problem space almost immediately without the limitations imposed by text. However, our findings also revealed two important areas in need of improvement. First, students required much more practice in solving the subproblems (e.g., interpreting schematic plans) than we had originally thought. To enable students to better "visualize" the abstract math concepts embedded in the problems, we added media-based interactive tools (e.g., rotatable three-dimensional objects) and hands-on applications (e.g., designing and building hovercrafts). Our studies also revealed that the problem-solving activities by themselves did little to improve the fractions computation skills of some students. To correct this problem, we developed a set of computer-based modules to boost students' understanding of and computation with fractions (Bottge, Rueda, Grant, Stephens, & LaRoque, 2010).

The strategic modifications to our instructional methods, which we call *enhanced anchored instruction* (EAI), align closely with recommendations in the Institute of Education Sciences' *Practice Guide for Organizing Instruction to Improve Student Learning* (Pashler et al., 2007) and of the National Mathematics Advisory Panel (NMAP; 2008). By adding multiple representations of problems and more direct teaching of fractions, we hoped to avoid overloading students' working memory, which is an increasing concern as problems become more complex (Geary, Hoard, Nugent, & Bailey, 2012). Previous versions of EAI have produced promising results in a series of studies conducted in various instructional settings involving students with learning disabilities (e.g., Bottge et al., in press) and behavior disorders (e.g., Bottge, Rueda, & Skivington, 2006).

Study Targets

Despite the trend that students with disabilities are spending more of the school day in general education classrooms (U.S. Department of Education, 2007) and the promise of least restrictive environment to boost performance (Scruggs, Mastropieri, & Mcduffie, 2007), the academic outcomes for students with MD remain low. A practical and increasingly popular solution to including students with disabilities in general classrooms has been co-teaching, also known as collaborative or cooperative teaching. According to Cook and Friend (1995), *co-teaching* is defined as "two or more professionals delivering substantive instruction to a diverse, or blended, group of students in a single physical space" (p. 1).

The critical feature of co-teaching is that two teachers simultaneously and actively teach for a planned and scheduled part of the day, with the underlying philosophy that both educators are responsible for all students (Hourcade & Bauwens, 2001). Traditional co-teaching models include the following: (a) one person teaching and one person, usually the special educator, providing assistance or support by circulating and answering individual questions; (b) station teaching, whereby each co-teacher provides a particular learning activity or center while students rotate between teachers; (c) parallel teaching, with each teacher teaching the same content but to two different, heterogeneous groups simultaneously; (d) alternative teaching, whereby the two teachers present different material to two groups, often with the general educator reviewing content while the special educator reteaches content for some students; or (e) team teaching, whereby both teachers actively instruct the same group together (Vaughn, Schumm, & Arguelles, 1997).

Our goal in this study was to test the effects of the revised EAI units on students with MD in inclusive middle school math classrooms. Given the emphasis in K–12 education on matching instruction to the Common Core State Standards in Mathematics (CCSS-M; National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), studies evaluating instructional practices are all the more important. Specifically, we designed the study to answer the following research questions:

1. What are the differential effects, if any, of EAI and business-as-usual (BAU) instruction on the fractions, computation skills, and problem-solving performances of students with and without MD in inclusive math classes?
2. Do collaborative instructional strategies moderate the math performances of students with and without MD and, if so, how?

Method

Participants

The study was conducted in 25 inclusive math classrooms in 24 middle schools located in urban and rural counties in the Southeast (a second math class participated in one of the EAI schools). The University Office of Research Integrity approved the study. Schools were randomly assigned to the EAI or BAU condition, which resulted in 12 in each condition. Table 1 displays demographic information. BAU math and special education teachers were slightly more experienced and had more graduate training than EAI teachers, although the difference was not statistically significant. There were no teacher differences for gender or ethnicity by instructional group.

Of the 248 BAU and 223 EAI students who participated, 72 (29%) and 62 (28%) students had an identified disability, respectively. Students were comparable across conditions in ethnicity, subsidized lunch, and disability area. Students were receiving special education services for mild mental disability (MMD), other health impairment (OHI), specific learning disability (SLD), autism, or emotional and behavioral disorders (EBD).

Table 1. Teacher and Student Characteristics.

Variable	*n*				
	BAU	EAI	χ^2	*t*	*p*
Special education teachers	12	13			
Gender			0.37[a]		.70
Male	5	7			
Female	7	6			
Ethnicity			0.39		.53
Caucasian	10	13			
African American	2	0			
Years teaching special education				1.66	.11
M	12.58	8.00			
Median	12.00	6.00			
SD	6.96	6.66			
Range	2–32	1–23			
Highest degree earned			2.49[a]		.20
BA, BS	2	6			
MA, MS	10	7			
Math teachers	12	13			
Gender			1.10[a]		.38
Male	8	11			
Female	4	2			
Ethnicity			0.04		.84
Caucasian	12	13			
Years teaching general education				1.02	.32
M	10.92	8.15			
Median	10.00	4.00			
SD	6.27	7.16			
Range	2–23	2.22			
Highest degree earned			1.96[a]		.32
BA, BS	1	4			
MA, MS	11	9			
Students with MD	72	62			
Gender			0.51[a]		.48
Male	55	44			
Female	17	18			
Grade			0.07[a]		.99
6	6	6			
7	66	53			
8	0	3			
Ethnicity			1.19[b]		.53
Caucasian	51	39			
African American	16	16			
Latino	4	2			
Asian	0	4			
Biracial and Other	1	1			
Disability/service area			4.69[b]		.33
MMD	7	4			
OHI	30	31			
SLD	16	16			
Autism	1	3			

(continued)

Table 1. (continued)

Variable	n BAU	n EAI	χ^2	t	p
EBD	8	8			
Other	10	0			
Math achievement (pretest M)					
Fractions Computation Test	10.89	9.91		0.48	.63
Problem Solving Test	16.13	16.21		–0.06	.95
ITBS Computation	14.88	14.51		0.34	.73
ITBS Problem Solving and Data Interpretation	13.34	12.64		0.80	.43
Students without MD	176	161			
Gender			5.73[a]		.02
Male	85	104			
Female	91	57			
Grade			4.51[a]		.04
6	22	34			
7	154	127			
8	0	1			
Ethnicity			3.37[b]		.19
Caucasian	138	120			
African American	28	23			
Latino	7	11			
Asian	2	4			
Biracial and Other	1	3			
Math achievement (pretest M)					
Fractions Computation Test	14.00	15.74		−1.12	.26
Problem Solving Test	20.20	20.89		–0.91	.36
ITBS Computation	16.94	18.12		−1.87	.06
ITBS Problem Solving and Data Interpretation	14.61	15.38		−1.43	.16

Note. BAU = business as usual; EAI = enhanced anchored instruction; EBD = emotional and behavioral disorders; ITBS = Iowa Tests of Basic Skills; MMD = mild mental disability; OHI = other health impairment; SLD = specific learning disability. Less populated categories combined (or ignored) for chi-square test: special education teacher ethnicity reduced to Caucasian, African American ignored; special education student grade reduced to 6 and 7–8; special education and general education student ethnicity reduced to Caucasian, African American, and Latino/Asian/Biracial and Other; disability/service area reduced to MMD, OHI, SLD, EBD, not applicable, and autism or other. Two special education teachers were assigned to two classrooms in the EAI condition, but all classrooms only used one special education teacher. The primary special education teacher was used for reporting purposes.
[a]Fisher's exact test.
[b]Monte Carlo method based on 10,000 sampled tables.

Detailed descriptions of each disability are available from the National Dissemination Center for Children With Disabilities (see http://nichcy.org/disability/categories#id).

The class size of BAU classes ($M = 20.67$, $SD = 5.98$) was slightly larger than that of EAI classes ($M = 17.23$, $SD = 4.89$), as was the number of students with MD in BAU classes ($M = 6.00$, $SD = 1.60$) compared to EAI classes ($M = 4.77$, $SD = 2.32$), but the class size differences, $t(23) = 1.58$, $p = .13$, and the number of included MD students, $t(23) = 1.54$, $p = .14$, were not significantly different. All but two schools (one in each condition) received Title I assistance. More than half of the students in the schools (54%) received free or reduced-price lunch, and the percentage of students receiving free or reduced-price lunch in the EAI schools (M = 34.40, SD = 12.42) and BAU schools (M = 54.61, SD = 23.34) did not differ, $t(19) = -0.15$, $p = .88$.

In addition to student individualized education programs (IEPs) that indicated math a service area, two standardized subtests of the Iowa Tests of Basic Skills (ITBS; Form C, Level 12; University of Iowa, 2008) were administered as pretests and helped to confirm the low achievement in math of students with disabilities in our study: Mathematics Computation (M = 14.74 < ITBS mean raw score of 18.2) and Problem Solving and Data Interpretation (M = 12.99 < ITBS mean raw score of 15.0). According to the ITBS (Form C, Level 12) national norms (Dunbar et al., 2008, p. 26), students with disabilities in this study (i.e., majority being in Grade 7) were on average 0.6 standard deviations below the fall national norm in computation and 0.4 standard deviations below the national norm in problem solving for students in Grade 6. Prior to instruction, BAU and EAI groups within each disability status group were comparable on both standardized measures and on the researcher-developed tests.

Study Overview

To answer the first research question, we conducted a pretest-posttest, cluster-randomized, school-based trial. Four math tests administered immediately before and after instruction assessed the effects of EAI on the students' computation and problem-solving skills. Tests were scored in ways that yielded both whole-test results and item-level errors.

Project personnel, who had been trained and had observed 324 class sessions for a similar study the previous year, conducted a total of 285 whole-class period observations (191 and 94 in EAI and BAU classrooms, respectively). They recorded field notes directly into templates we customized using FileMaker Pro 10 which included areas for collecting demographic information (date, school, condition, unit of instruction), rating categories for indicating level of treatment fidelity (*s*urface features such as following lesson plan activities, quality of implementation), and open spaces for describing classroom activities. The observer collection form also included checkboxes for indicating the primary co-teaching model (one teach/one assist, station teaching, parallel teaching, alternative, team teaching or co-teaching), which, along with the narrative descriptions of classroom activities, were used to answer the second research question.

A second observer was present at 41 class sessions (30 EAI, 11 BAU), which accounted for 14% of the total. Interobserver agreement averaged 90% (EAI = 87%, BAU = 91%) and was assessed using point-by-point comparisons for each checkbox and rating scale.

To help us answer the second research question, prior to analyzing the test results, we identified teachers who employed more supportive collaborative models (e.g., one teach/one assist) from those that used less supportive models (e.g., one teach/one observe, no co-teaching). First, we conducted a thorough review of the narrative descriptions of teachers' activities to help verify the observers' accuracy in labeling the co-teaching model on the observation template. Second, once the observation models were verified, the observers read all of their records again and rank-ordered the classrooms from high support to low support. *High support* meant that the special education teacher actively taught much of the curriculum along with the math teacher. In *low-support* classrooms, the special education teacher mainly observed. Finally, using all relevant information (i.e., primary collaborative model, narrative description within observation records, observer input), five members of the research team reached consensus on ordering of high-support and low-support classrooms.

EAI Condition

The five EAI units targeted several of the CCSS-M standards, especially ratios and proportional relationships, number system–fractions, statistics and probability, and geometry–graphing. We provided teachers with daily lesson plans that included the lesson objectives, materials, warm-up exercises, and detailed descriptions of how to implement each lesson (see Professional Development). The five EAI units included a mix of computer-based interactive activities, video-based anchored problems, and hands-on applied projects. The lessons included explicit instruction on procedural computation and PBL-like problem-solving activities. The average number of instructional days was 66 and 71 for EAI and BAU classes, respectively. Class sessions in both conditions ranged from 45 to 75 min, but one class in each condition met in 90-min blocks.

The first unit, Fractions at Work (FAW), consisted of an author-developed computer-based application and hands-on activities designed to provide students with conceptual understanding of and procedural skills with simple fractions and mixed numbers. Every lesson was designed to maintain teachers' important role in clarifying, supporting, and reinforcing the learning objectives. For example, teachers taught students with concrete materials, such as fraction strips, to help them understand the concept of equivalence. Students used their fraction strips to solve problems, such as "If you have 1/2 of a stick of gum and your friend has 1/4 of a stick, who has more?" and "How much more does she have?" The first chapters of FAW were devoted to basic concepts, such as the purpose and function of fractions, the notion of equivalence, and why it is not appropriate to add and subtract denominators. Some computer screens displayed an interactive tape measure to help show that the value of fractions depends on the number of parts into which an inch is divided (i.e., denominator) and the number of these parts available (i.e., numerator). In successive chapters, students were shown how to add simple fractions with like and unlike denominators, how to add and subtract mixed numbers, and how to rename and simplify fractions. The software also provided formative checks of students' skills. This unit took classes an average of 15 instructional days to complete.

The first anchored problem, Fraction of the Cost (FOC), contained an 8-min video and several interactive tools to help students solve the subproblems leading to the overall solution. The video portrays three friends who wish to build a skateboard ramp from a schematic plan and stay under budget. In doing so, they must show in what combinations of lengths of boards they should cut to waste as little wood as possible. To solve the problem, students needed to (a) calculate percentage of money in a savings account and sales tax on a purchase, (b) read a tape measure, (c) convert feet to inches, (d) decipher building plans (side view of ramp is a right triangle), (e) construct a table of materials, (f) compute mixed fractions, (g) estimate and compute combinations, and (h) calculate total cost. The unit focused on several of the Grade 7 Common Core standards, especially ratios and proportionality (i.e., solving problems about scale drawings, computing taxed amounts), understanding of number (i.e., computing whole numbers and fractions), and geometry (i.e., solving problems involving scale drawings of geometric figures). Teachers taught FOC for an average of 11 instructional days.

The third unit consisted of a hands-on problem, called the Hovercraft Challenge (HOC), that engages students in applying the skills they learned in the two previous units, especially measurement and using scale drawings and geometric constructions. The final task of the unit required students to design a hovercraft "rollover cage," draw it to scale, and build it out of PVC pipe. The payoff for students was "race day," when they rode their hovercrafts. Leaf blowers inserted into a plywood platform powered the hovercrafts. The air was forced through small holes in a plastic sheet fastened to the underside of the hovercraft base, which lifted it off the floor. Students designed their own rollover cages for their hovercraft, which had to include knee, side, and head protection and meet several design specifications (e.g., four feet long, three feet wide). Students were taught to draw schematic plans to scale on graph paper (one quarter of an inch equal to two inches of pipe) and how to display their cage's side and top views. The cost of the design (and materials) had to meet a prespecified budget and, like the FOC unit, forced students to figure out how to use materials in the most economical way. After teachers approved the plans, students built a scale model out of plastic straws. Using the schematic plans and scale models, students worked in small groups to measure, cut, and assemble their full-sized cages. On the final day of the unit, students attached their rollover cage to the hovercraft and took turns riding them through the hallways of their school. This unit is complex and took classes 22 instructional days to complete.

Kim's Komet (KK) is a video-based unit and an episode in a series called *The New Adventures of Jasper Woodbury* (Learning and Technology Center at Vanderbilt University, 1997). The video anchor involves two girls who compete in a competition that requires them to predict where on a ramp they should release their cars to navigate five tricks (double hump, short jump, loop-the-loop, banked curve, and long jump) attached to the end of straightaway. In the first section of KK, students learn how to calculate speeds when times and distances vary. The next challenge asked students to use their own stopwatches to time Kim's car in the video time trials. On the basis of their findings, students learned that they should time Kim's car on the straightaway when the car's speed is relatively constant. Students plotted the speeds of Kim's car on their graph for each of the release points and then drew a line of best fit. Students used this line to predict speeds for all possible release points on the day of the competition. KK was designed to help students develop their informal understanding of pre-algebraic concepts, such as linear function, line of best fit, variables, rate of change (slope), reliability, and measurement error. Foundation skills needed to solve this problem include computation with whole numbers and rational numbers (i.e., decimals).

After students solved the KK video-based problem, they competed in their own Grand Pentathlon (GP) competition with a full-sized ramp and events. We provided students their own cars, which they timed from several release points on the ramp. An infrared detector measured the time of the cars from the beginning to end of the straightaway. After students made their graphs and plotted their times, the teacher revealed to students the range of speeds within which their cars should be traveling to negotiate each event. Students had to construct their graphs and lines of best fit to predict the speed of their own cars at the end of the straightaway for every release point on the ramp. The KK and GP units were completed in 18 instructional days.

Professional Development

A middle school math teacher who had several years of experience teaching with EAI conducted a 2-day, 14-hr summer workshop that was attended by pairs of math and special education teachers from the schools that had been randomly assigned to the EAI condition. Previous studies with the EAI units indicated that teachers needed high-quality professional development to teach the multimedia-based units (i.e., FOC, Fractions at Work, KK) and hands-on projects (i.e., HOC, GP) with fidelity. We also recognized from our previous studies that some special education teachers required more in-depth explanations of math concepts (e.g., reliability and measurement error, drawing schematic plans to scale). The instructor modeled problem-solving and explicit teaching strategies for teachers, who were then provided multiple opportunities to play the part of "students" during sample lessons. Portions of the training segments were available for EAI teachers to review during the school year on a password-protected web site.

BAU Condition

The BAU teachers followed their districtwide math curriculum, which was aligned with the Kentucky Core Academic Standards and Combined Curriculum Document from the Kentucky Department of Education. The teachers' self-reports and lesson plans, together with our classroom observations, suggest that the math objectives in BAU classrooms paralleled those of the EAI units. Calendar Math (Gillespie & Kanter, 2000) was a daily part of the math instruction in several BAU classrooms. Teachers and students also used technologies, such as computers and interactive whiteboards, along with manipulatives. To give the reader an idea of the types of BAU instructional activities, we provide summary accounts of several lessons.

In one math classroom, two main units were focused on ratios and proportional relationships and on operations with fractions. At the beginning of each class, the math teacher restated lesson objectives as a "student-friendly version" (or "*I can* statement"), which students entered into their math journals. Then, class started with teacher-made warm-up activities (e.g., bell ringer, sponge questions), which took from 5 to 10 min. The warm-up questions were either review questions from the previous lesson or basic math computation problems that were related to the current lesson. Students were asked to work independently, and then teachers discussed with students the answers to the problems. Teachers briefly reviewed the previous topic as needed. After the warm-up activities, teachers presented connections from a real-world phenomenon to the current topic. For example, teachers used coins and asked questions about creating fractions (e.g., $1 can be divided into four quarters) and how fractions can be used in the real world.

In most classes, teachers used procedural instruction as their strategy to deliver the main content. Teachers showed how to solve mathematical problems, and students were encouraged to follow the step-by-step procedures. Formative assessment was ongoing to check students' mastery level, using random questions, teacher observations, or small quizzes, which allowed teachers to reteach and review the contents and provide additional instruction as needed. Students worked in small groups much of the time.

Hands-on (or project-based) activities, web-based instruction, or drill and practice were also used throughout the study period. For example, each student was assigned a certain number of fractions (1/2, 2/5, 3/10, etc.) and then was asked to arrange them from smallest to largest. To complete this activity, students needed to review the previous lesson, work with partners, or use additional support such as calculators. Another project-based example involved calculating unit rate (e.g., ratio and proportional relationships) from several grocery ads. Teachers brought grocery flyers from local grocery stores and encouraged students to find which store offered a better deal for grocery items. For example, Walmart had three dozen eggs for $4.50 compared to Kroger, which sold two dozen eggs for $2.50. Students calculated "unit rate" to answer which store offered a better deal (e.g., $4.50/3 = $1.50 at Walmart vs. $2.50/2 = $1.25 at Kroger).

Math Measures

Two researcher-developed tests and two standardized achievement tests were administered over 3 consecutive days immediately prior to and following the instructional period. A second rater independently scored 20% of the pretests and posttests.

Fractions Computation Test (FCT). A 20-item (14 addition, six subtraction), 42-point, researcher-developed test measured students' ability to add and subtract simple fractions and mixed numbers with like and unlike denominators. All but one of the items on the FCT included fractions that could be found on a ruler. The test also included items that required students to add three fractions. Students were told to reduce their answers to simplest form and to show all their work. Calculator use was not allowed. On 18 of the items, students earned 1 point for showing correct work and 1 point for the correct answer. On two items with mixed numbers that required renaming prior to subtracting, students were awarded an additional point. Internal consistency estimates were .96 (95% CI [.95, .97]) at pretest and posttest for students with MD and .97 (95% CI [.96, .97]) at pretest and .96 (95% CI [.95, .97]) at posttest for students without MD. Interrater agreement was 99% on the pretest and 97% on the posttest.

Problem Solving Test (PST). A 21-item, 35-point, researcher-developed test sampled the problem-solving skills of students and, specifically, their conceptual understanding of ratios and proportional relationships, number system–fractions, statistics and probability, and geometry–graphing as described in the CCSSI-M (2010) standards. All but two of the items on the PST were in open-response formats; presented a question about a figure, table, or graph; and provided an answer box where students were to show their work. Students could earn partial credit on items for showing they knew how to solve the problem and full credit for the correct answer. Readability tests indicated the reading level was at or below the fourth grade, and students were allowed to use calculators.

Some items asked students to solve a word problem by computing time given rate and distance. Other items provided a table of variables that students used to plot points on a graph and then sketch a line of best fit. One PST item showed a table of building materials and asked students to figure out the most economical lengths of wood to buy. Students had to use repeated addition (or multiplication) and subtraction of whole numbers and rational numbers expressed as fractions and decimals. Other items asked students to determine a length given a measurement scale (i.e., one square of building plan equals 2 inches), calculate 10% of a bank balance (i.e., finding a percentage of a quantity as a rate per 100), and show fractions on a number line.

Versions of the PST went through cycles of refinement based on student performances in previous research, suggestions from math and assessment specialists (i.e., math teachers, math researchers, test consultants), and piloting them with a class of middle school students who were not involved in the study. Based on reviewers' suggestions, we reworded some of the items and redrew the figures. Internal consistency estimates were .80 (95% CI [.75, .85]) at pretest and.86 (95% CI [.83, .90]) at posttest for students with MD and .80 (95% CI [.76, .83]) at pretest and .83 (95% CI [.80, .85]) at posttest for students without MD. Interrater agreement was 95% on the pretest and 93% on the posttest.

ITBS. The ITBS (Form C, Level 12; University of Iowa, 2008) is a norm-referenced standardized achievement test that was used to complement the researcher-developed tests. Two math subtests of the ITBS were administered according to the directions in the test administration booklet, but all students were allowed to enter their answers directly into their test booklet, a procedure identified as an accommodation for students with MD.

The 30-item ITBS Computation (ITBSC) subtest required students to perform one of the four arithmetic operations (addition, subtraction, multiplication, or division) with whole numbers, fractions, and decimals. Eight of the items assessed adding and subtracting fractions (four addition, four subtraction). Students worked each problem and then selected their answer from three choices or *N* if students thought the answer was not one of the choices. Internal consistency estimates of the ITBSC were .85 (95% CI [.80, .88]) at pretest and posttest for students with MD and .83 at pretest (95% CI [.80, .86]) and posttest (95% CI [.81, .86]) for students without MD. Internal consistency estimates of the eight fractions subset of items were .67 (95% CI [.58, .75]) at pretest and .68 (95% CI [.59, .76]) at posttest for students with MD and .65 (95% CI [.59, .71]) at pretest and .68 (95% CI [.62, .73]) at posttest for students without MD. Interrater reliability was 100% on the pretest and the posttest.

The 28-item ITBS Problem Solving and Data Interpretation (ITBSPS) subtest consisted of problems in several formats that took one or more steps to solve. Per test administration instructions, students were allowed to use calculators. Of the items at this test level, 12 were word problems and four required students to use data displays to obtain information and compare quantities. Other items asked students to interpret graphs, charts, and tables. Internal consistency estimates were .80 (95% CI [.74, .84]) at pretest and .75 (95% CI [.68, .81]) at posttest for students with MD and .80 (95% CI [.77, .83]) at pretest and .78 (95% CI [.74, .81]) at posttest for students without MD. Interrater reliability was 100% on the pretest and the posttest.

Data Analysis

One inclusive math class from each school (with the exception of one school that had two inclusive math classes) was sampled, and thus we employed a two-level multilevel model (MLM; student, teacher) to evaluate the effect of the treatment condition on student performance (Raudenbush & Bryk, 2002). We also tested for whether possible treatment effects were moderated by quality of instructional support (co-teaching practices), adjusted for pretest scores on the respective math outcome measures. All models were fit separately for students with and without MD using SPSS 20.0 MIXED procedure with restricted (residual) maximum likelihood estimation, which uses all available data except those missing on a primary outcome measure.

The Level 1 model was situated at the student level, which included pretest and posttest scores. Using the researcher-developed FCT score as an example, with FCT1 as the pretest score and FCT2 as the posttest score, the Level 1 model was

$$\mathrm{FCT2}_{ij} = \beta_{0j} + \beta_{1j}\mathrm{FCT1}_{ij} + \varepsilon_{ij}, \quad (1)$$

where $\mathrm{FCT2}_{ij}$ is the fraction computation score after the treatment (posttest) for student i with teacher j, $\mathrm{FCT1}_{ij}$ is the computation score before the treatment (pretest) for the same student, and ε_{ij} is an error term unique to each student, assuming $\varepsilon_{ijk} \sim N(0, \sigma^2)$. The average computation posttest score of students is represented by β_{0j} for teacher j adjusted for fraction computation pretest scores (grand mean centered) of students for that teacher, and β_{1j} is the regression coefficient for the fraction computation pretest score for that teacher.

The Level 2 model was situated at the teacher level and included quality of support, treatment condition (one dummy variable with BAU as the group against which EAI was compared), and interaction between treatment condition and quality of support (with quality of support represented as one dummy variable with low quality as the group against which high quality was compared). The Level 2 model was

$$\beta_{0j} = \gamma_{00} + \gamma_{01} + \mathrm{Support}_j + \gamma_{02}\mathrm{EAI}_j + \gamma_{02} \; \mathrm{EAI} \times \mathrm{Support}_j + u_{0j}, \quad (2)$$

$$\beta_{1j} = \gamma_{10}, \quad (3)$$

where γ_{00} is the average posttest fraction computation score adjusted for the treatment condition (EAI vs. BAU), quality of support, and interaction between treatment condition and quality of support (EAI × Support); γ_{01} is the regression coefficient for quality of support; γ_{02} is the regression coefficient for the treatment condition; γ_{03} is the regression coefficient for the interaction, which represents the moderating effect that quality of support has on the treatment effect; γ_{10} is the pooled regression coefficient for the fraction computation test before treatment (pretest); and u_{0j} is an error term unique for each teacher, assuming $u_{0j} \sim N(0, \tau_\pi^{\,2})$.

The interaction between pretest scores and study variables can be an issue in experimental designs. We examined this interaction in a two-step approach. First, the coefficient of the pretest variable that represents the effect of pretest on posttest was set as random at the teacher level. If this effect does not have statistically significant variance across teachers, the slope of pretest onto posttest scores is the same across teachers, implying that the pretest-posttest slope is not moderated by treatment or support. Second, if the effect does not have statistically significant variance across teachers, the treatment condition, support variable, and treatment-by-support interaction are used to model the variation in the effect of pretest on posttest. If any of the treatment condition, support, or treatment-by-support interaction effects are statistically significant, then the pretest-posttest slope is moderated by the study variable(s). We performed this procedure on our outcome measures separately for students with and without MD. Only one outcome measure (ITBSPS) showed statistically significant variation in the pretest-posttest slope at the teacher level within the group of students without MD. However, the study variables were not statistically significant in this case. We concluded that there was no concern about the interaction between treatment condition or level of teacher support with pretest scores.

Results

Math Performance

Table 2 shows means and standard deviations of pretest and posttest scores on each outcome measure for students with and without MD by each type of treatment condition (EAI vs. BAU). Table 3 provides the final MLM results directly relevant to our research questions. The coefficient estimate (γ_{02}) addresses our first research question and represents the estimated difference between the means of EAI and BAU posttest scores adjusted for pretest scores on the respective outcome and other teacher level variables.

An MLM was fit to each outcome variable within each type of student group (i.e., students with and without MD) to test whether there was an interaction between treatment condition and quality of support, which addresses our second research question. The interaction between treatment condition and quality of support was found for students with MD on the FCT but not for any other outcome measure, and we therefore fit the MLM to all remaining outcome measures without the interaction term.

Overall, scores for students with and without MD in EAI classes were higher than those in BAU classes on the researcher-developed tests aligned to the four CCSSI-M standards. Results of the FCT results showed the interaction term was statistically significant for students with MD, $\gamma_{03} = 11.11$, $p = .03$, indicating that the quality of support moderated the treatment effect. That is, EAI students who received more special education teacher support scored significantly higher on posttest scores (effect size [ES] = 1.15) than BAU students, but the magnitude of this difference was not statistically significant for lower levels of support (ES = .29). A statistically significant treatment effect was also found in favor of EAI students without MD for the FCT, $\gamma_{02} = 8.44$, $p = .001$, ES = .61. On the PST, statistically significant treatment effects were found for EAI over BAU both for students with MD, $\gamma_{02} = 3.98$, $p = .02$, ES = .47, and without MD, $\gamma_{02} = 2.65$, $p = .02$, ES = .38.

No statistically significant differences overall were found on the norm-referenced ITBSC and ITBSPS subtests for students with and without MD. However, on a subset of eight fraction computation items from the ITBSC analyzed separately, students without MD who were in EAI classes had statistically significant higher posttest scores than students without MD who were in BAU classes, $\gamma_{02} = 0.55$, $p = .04$, ES = .32. However, these should be interpreted with some caution given the relatively low level of score reliability for the subset of items. There was no difference for students with MD by treatment condition, $\gamma_{02} = 0.34$, $p = .46$, ES = .08.

Portions of Table 3 are devoted to measures of the adequacy of the MLMs by means of R^2 estimates. The range of R^2 estimates for MLMs that demonstrated statistically significant treatment effects was from .18 to .52. In this range, one MLM had an R^2 estimate between .13 and .19, whereas four MLMs had R^2 estimates above .30. Using Gaur and Gaur's (2006) standard, all of the MLMs were adequate in capturing variance in adjusted posttest scores.

The MLM analyses yielded variance components at different levels (student [σ^2] and teacher [τ_π^2]), which is an estimated partition of the total sample variance in a certain outcome measure. Variance components for each level are not provided because of space restrictions, but they can be obtained from the first author.

Co-Teaching Patterns

Observational data from the 25 classrooms showed distinct patterns of co-teaching across conditions. One teach/one assist proved to be the most common delivery method (44%), whereas team teaching was seldom observed (17%). During one teach/one assist, the general educator almost always took the instructional lead while the special educator provided support to students by circulating throughout the room to respond to questions, clarify content or instructions, or provide cues to students. During team teaching, the general educator and

Table 2. Descriptive Statistics for Students With (n = 134) and Without (n = 337) Disabilities in Math (MD) on Fraction Computation Test (FCT), Problem Solving Test (PST), Iowa Test of Basic Skills Computation (ITBSC), and ITBS Problem Solving and Data Interpretation Test (ITBSPS) by Treatment Condition (BAU vs. EAI).

	Students with MD								Students without MD							
	BAU				EAI				BAU				EAI			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
Outcome	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
FCT (42)	10.99	12.97	13.48	13.74	9.91	11.34	22.39	13.75	14.00	13.92	18.81	13.96	15.74	14.04	29.01	13.43
PST (35)	16.13	6.98	18.66	8.39	16.21	7.50	22.70	8.24	20.20	7.44	23.13	7.02	20.89	6.44	26.10	6.67
ITBSC[a] (30)	14.88	6.60	17.82	6.44	14.51	5.17	16.44	5.32	16.94	5.68	18.26	5.80	18.12	5.48	19.66	5.22
	(4.63)	(1.92)	(5.19)	(1.98)	(4.29)	(1.82)	(5.44)	(1.73)	(5.07)	(1.69)	(5.53)	(1.78)	(5.27)	(1.83)	(6.25)	(1.64)
ITBSPS (28)	13.34	5.17	13.87	4.62	12.64	4.51	14.80	4.24	14.61	5.08	16.27	4.38	15.38	4.60	17.61	4.62

Note. BAU = business as usual; EAI = enhanced anchored instruction. Sample sizes for students with MD on outcome measures varied from 123 (FCT and ITBSC), 126 (ITBSPS), and 132 (PST), whereas for students without MD, samples sizes varied from 316 (ITBSC), 323 (FCT), and 334 (PST). Each of the outcome measures has been aligned to the Common Core State Standards Initiative–Mathematics (2010). Space limitations prohibited inclusion of the table. Copies of the outcome measures and the alignment can be obtained from the first author. Values in parentheses below each outcome measure represent the number of points possible.

[a]Values in parentheses are the subset of eight fraction computation items from the ITBSC.

Table 3. Final Multilevel Model Results for Students With and Without Disabilities in Math (MD) on Fraction Computation Test (FCT), Problem Solving Test (PST), Iowa Test of Basic Skills Computation (ITBSC), and ITBS Problem Solving and Data Interpretation Test (ITBSPS).

		Students with MD				Students without MD			
Outcome	Parameter	Est.	*SE*	ES	R^2	Est.	*SE*	ES	R^2
FCT (*n* = 123, 323)	Intercept, γ_{00}	14.23***	2.35		.52	18.52***	1.98		.34
	Pretest, γ_{10}	0.74***	0.07			0.54***	0.05		
	Support, γ_{01}	−1.85	3.25			1.99	2.28		
	EAI, γ_{02}	3.98*	1.63	0.26		8.44**	2.28	0.61	
	EAI × Support, γ_{03}	11.11*	4.74						
	EAI @ low support[a]	4.19	2.68	0.29					
	EAI @ high support[a]	14.82***	3.59	1.15					
PST (*n* = 132, 334)	Intercept, γ_{00}	18.42***	1.42		.46	22.71***	0.87		.48
	Pretest, γ_{10}	0.77***	0.07			0.64***	0.04		
	Support, γ_{01}	0.05	1.63			0.88	1.00		
	EAI, γ_{02}	3.98*	1.63	0.47		2.65*	1.00	0.38	
ITBSC[b] (*n* = 123, 316)	Intercept, γ_{00}	17.92*** (5.37***)	1.11 (0.38)		.28 (.16)	18.21*** (5.56***)	0.56 (0.21)		.29 (.18)
	Pretest, γ_{10}	0.57*** (0.42**)	0.08 (0.09)			0.53*** (0.40***)	0.05 (0.05)		
	Support, γ_{01}	−0.39 (−0.56)	1.29 (0.44)			0.93 (0.11)	0.64 (0.25)		
	EAI, γ_{02}	−1.31 (0.34)	1.29 (0.44)	0.22 (0.08)		0.57 (0.55*)	0.64 (0.24)	0.10 (0.32)	
ITBSPS (*n* = 126, 325)	Intercept, γ_{00}	13.54***	0.59		.29	16.36***	0.50		.36
	Pretest, γ_{10}	0.51***	0.07			0.52***	0.04		
	Support, γ_{01}	0.30	0.68			0.20	0.58		
	EAI, γ_{02}	1.31	0.68	0.29		0.69	0.58	0.15	

Note. Est. = coefficient estimate; EAI = enhanced anchored instruction. SPSS Version 20.0 does not allow missing values on outcome variables, and thus the data analysis was based on numbers of students (indicated by *n*) with and without disabilities, respectively, who had valid scores on the posttest for each cognitive measure. R^2 = estimated proportion of overall variance in outcome scores explained by the model. $\text{ES} = \dfrac{\gamma_{02}}{\sqrt{\dfrac{(n_1-1)S_1^2+(n_2-1)S_2^2}{(n_1+n_2-2)}}}\left(1-\dfrac{3}{4(n_1+n_2)-9}\right)$, where γ_{02} represents the mean difference in posttest scores between EAI and business-as-usual (BAU) groups adjusted for pretest scores on the respective outcome, student characteristics at Level 1, and teacher characteristics at Level 2; n_1 and n_2 are EAI and BAU sample sizes, respectively; S_1 and S_2 are the student-level unadjusted posttest standard deviations for EAI and BAU groups, respectively.

[a]Simple effect tests of EAI at each level of support (low, high) using unique error terms.

[b]Values in parentheses represent results from the multilevel model fit to the subset of eight fraction computation items from the ITBSC.

**p* < .05. ***p* < .01. ****p* < .001.

special educator each took the instructional lead at alternate points in the lesson. In 21% of classroom observations, no co-teaching model was observed. The other collaborative models (e.g., station teaching, parallel teaching, alternative teaching) were rarely observed as the primary co-teaching model. Regardless of instructional condition, the special educator commonly assumed a secondary role in the classroom and employed instructional strategies that would assist students without disrupting the primary instruction of the general education teacher (e.g., circulating and prompting). In classrooms judged more supportive, the special education teacher provided explicit help to students with MD. For example, while the general education teacher explained the mathematical concept aloud, the special educator provided a visual model on the whiteboard.

One teach/one assist proved to be the most common delivery method, whereas team teaching was seldom observed.

The special educator commonly assumed a secondary role in the classroom.

Discussion

The purpose of this study was twofold. First, we examined possible effects of EAI on students' fractions computation and problem-solving skills in inclusive math classes. Results were positive in favor of EAI for students with and without MD on the researcher-developed tests that measured skills in computing with fractions and problem solving. We are especially encouraged by these findings because the items were aligned with the CCSS-M, specifically ratios and proportional relationships, number system–fractions, statistics and probability, and geometry–graphing. Most impressive were the gains of students with MD in computing with fractions. Their mean FCT posttest score was almost 4 points higher than that of students without MD who were in the BAU classrooms. Students without MD in the EAI math classes made similar gains and also improved on the fractions items in the ITBSC. In addition, analysis of the error patterns that students made on FCT shows the most frequent mathematical error, regardless of treatment group and type of student, was adding or subtracting denominators, which is consistent with previous research (Bottge et al., in press).

Much of the explanation for the improvement of students with and without MD in the EAI classes can be traced to elements in the key model (Bottge, 2001), which is a theoretical representation of a foundation for teaching and learning math. For example, scholars in the general education math community assert that basic skills development and work on engaging problems need not be mutually exclusive (e.g., Carpenter, Fennema, Peterson, Chiang, & Loef, 1989) and that gains in one area can lead to gains in the other (e.g., Rittle-Johnson, Siegler, & Alibali, 2001). We agree that both sets of skills can be taught together for many students, but we suggest providing a period of explicit instruction on complex basic skills and concepts (e.g., understanding and computing fractions) prior to expecting students to use them in problem solving situations. Once they have learned the basics of the skills and the concepts supporting their use, students can gain more practice and facility while working on the anchored problems. Previous studies have shown that expecting students with MD to develop competence in both areas simultaneously can depress performances in each area (Bottge et al., 2010).

The second goal of this study was to explore the possibility that co-teaching practices moderated students' math performances. Results showed that this indeed was the case for the FCT but not for the other measures. In classrooms where the special education teachers shared direct teaching responsibilities with the math teachers, the effect size for fractions computation was more than one standard deviation. In the low-support classrooms, performance on the FCT was not significant, and the effect size was about one quarter of a standard deviation.

This finding aligns closely with a recent meta-analysis of co-teaching practices, which showed one teach/one assist to be the most popular model with special education teachers assuming a subordinate teaching role (Solis, Vaughn, Swanson, & Mcculley, 2012). The main issues preventing special education teachers from fully participating in the instruction included inadequate resources, planning time, and training on how to teach the math skill or concept. In this study, all of the special education teachers in the EAI condition were trained alongside their math colleagues, but only half of them took the initiative to actively co-teach parts of the fraction lessons during the intervention period. Despite removing the barriers that typically prevent special education teachers from assuming an active teaching role in inclusive general education classrooms (e.g., lack of training), several simply watched the math teachers teach the lessons.

Results also showed that there was no difference between high-support and low-support classrooms on the PST. During the anchored problem units, students with MD were assigned to problem-solving groups with their classmates. Much of this activity was conducted in these integrated groups, and students did not seem to require as much explicit instruction as they needed during the fractions computation instruction. The observational data documented that many of the students with MD brought a surprising amount of background knowledge to the anchored problems. Thus, explicit instruction by special education teachers was not as critical because students with MD understood the problem and drew support from their peers.

Many of the students with MD brought a surprising amount of background knowledge to the anchored problems.

Limitations

These findings are encouraging but we temper them with three limitations. First, as we have reported in other papers, we were somewhat dissatisfied with our researcher-developed problem-solving test. Teachers taught with interactive media and applied projects but assessed student competencies using paper-and-pencil tests. Although we had made improvements in the materials for this study, we need to develop better measures that provide more valid estimates of what mathematics students with MD know. Despite our efforts to word questions clearly and add graphics on our paper-and-pencil problem-solving tests, we suspect that some students were unsure of what the test items were asking.

Second, we did not find effects for EAI on the commercially developed standardized tests with the exception of the fraction computation items. We suspect that the format of the problem-solving test limited what students knew. In future work, we plan to make the transition from paper-and-pencil assessments to interactive, computer-based tests to help rid construct-irrelevant variance associated with problem decoding difficulties.

Third, we need to modify and add to our training by including explicit instruction on co-teaching strategies. This is not as critical for the hands-on activities because most students with MD have had few problems participating productively along with their peers without MD on the applied projects. However, special education teachers need to teach and act on the difficulties of students with MD as they are learning complex concepts.

Conclusions

This is the second of two large-scale randomized studies testing the effects of EAI among students with and without disabilities. The first study was conducted in resource rooms and showed that EAI was effective in improving students' computation and problem-solving skills (Bottge et al., in press). In the present study, we obtained similar results in co-taught math classes. What both studies demonstrate is that a thoughtful blend of explicit and anchored instruction can improve students' performance on mastering concepts included in the CCSS-M, which is a concern of other researchers in special education (e.g., Powell, Fuchs, & Fuchs, 2013).

A thoughtful blend of explicit and anchored instruction can improve students' performance on the Common Core standards.

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References

Baker, S., Gersten, R., & Lee, D. S. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *Elementary School Journal*, *103*, 51–73. doi:10.2307/1002308

Bottge, B. A. (2001). Reconceptualizing math problem solving for low-achieving students. *Remedial and Special Education*, *22*, 102–112. doi:10.1177/074193250102200505

Bottge, B. A., Heinrichs, M., Chan, S., & Serlin, R. (2001). Anchoring adolescents' understanding of math concepts in rich problem solving environments. *Remedial and Special Education*, *22*, 299–314. doi:10.1177/074193250102200505

Bottge, B. A., Ma, X., Gassaway, L., Butler, M., & Toland, M. D. (2014). Detecting and correcting fractions computation error patterns. *Exceptional Children, 80*, 237–255.

Bottge, B. A., Ma, X., Gassaway, L., Toland, M., Butler, M., & Cho, S. J. (in press). Effects of blended instructional models on math performance. *Exceptional Children, 80*, 237–255.

Bottge, B. A., Ma, X., Gassaway, L., Toland, M., Butler, M., & Cho, S. J. (2014). Effects of blended instructional models on math performance. *Exceptional Children, 80*, 423–437.

Bottge, B. A., Rueda, E., Grant, T. S., Stephens, A. C., & LaRoque, P. T. (2010). Anchoring problem-solving and computation instruction in context-rich learning environments. *Exceptional Children*, *76*, 417–437.

Bottge, B.A., Rueda, E., & Skivington, M. (2006). Situating math instruction in rich problems-solving contexts: Effects on adolescents with challenging behaviors. *Behavioral Disorders*, *31*, 394–407.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *17*(1), 32–41. doi:10.2307/1176008

Bruner, J. S. (1960). *The process of education*. New York, NY: Random House.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, P., & Loef, M. (1989). Using knowledge of children's mathematical thinking in classroom teaching: An experimental study. *American Educational Research Journal*, *26*, 499–531. doi:10.3102/00028312026004499

Cognition and Technology Group at Vanderbilt. (1997). *The Jasper Project: Lessons in curriculum, instruction, assessment, and professional development*. Mahwah, NJ: Lawrence Erlbaum.

Cook, L., & Friend, M.P. (1995). Co-teaching: Guidelines for creating effective practices. *Focus on Exceptional Children*, *28*, 1–16.

Coughlin, J., & Montague, M. (2011). The effects of cognitive strategy instruction on the mathematical problem solving of adolescents with spina bifida. *The Journal of Special Education*, *45*, 171–183. doi:10.1177/0022466910363913

Dunbar, S. B., Hoover, H. D., Frisbie, D. A., Mengling, M. A., Bray, G. B., Naylor, R. J., . . . Ordman, V. L. (2008). *Iowa Tests of Basic Skills/Core Battery: 2005 norms and score conversions, student norms and school average norms*. Rolling Meadows, IL: Riverside.

Dunlap, W. F. (1982). Readiness for story problems. *Academic Therapy*, *17*, 29–36.

Gaur, A.S., & Gaur, S.S. (2006). *Statistical methods for practice and research: A guide to data analysis using SPSS*. New Delhi, India: Response Books.

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2012). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. *Journal of Educational Psychology*, *104*, 206–223. doi:10.1037/a0025398

Gersten, R., Chard, D. J., Jayanthi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research*, *79*, 1202–1242. doi:10.3102/0034654309334431

Gersten, R., Clarke, B., & Mazzocco, M. (2007). Historical and contemporary perspectives on mathematical learning disabilities. In D. B. Berch, & M. M. M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities* (pp. 7–29). Baltimore, MD: Brookes.

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research*, *75*, 27–61. doi:10.3102/00346543075001027

Gillespie, J., & Kanter, P. F. (2000). *Every day counts calendar math*. Wilmington, MA: Great Source Education.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*, 99–107. doi:10.1080/00461520701263368

Hourcade, J. J., & Bauwens, J. (2001). Cooperative teaching: The renewal of teachers. *Clearing House*, *74*, 242–247. doi:10.1080/00098650109599200

Jitendra, A., DiPipi, C. M., & Perron-Jones, N. (2002). An exploratory study of schema-based word-problem-solving instruction for middle school students with learning disabilities: An emphasis on conceptual and procedural understanding. *The Journal of Special Education*, *36*, 23–38. doi:10.1177/00224669020360010301

Lave, J. (1993). Word problems: A microcosm of theories of learning. In P. Light & G. Butterworth (Eds.), *Context and cognition: Ways of learning and knowing* (pp. 74–92). Hillsdale, NJ: Lawrence Erlbaum.

Learning and Technology Center at Vanderbilt University. (1997). *The new adventures of Jasper Woodbury*. Mahwah, NJ: Lawrence Erlbaum.

Mastropieri, M. A., Berkeley, S., McDuffie, K., Graff, H., Marshak, L., Conners, N., . . . Cuenca-Sanchez, Y. (2009). What is published in the field of special education? An analysis of 11 prominent journals. *Exceptional Children*, *76*, 95–109.

National Center for Education Statistics. (2011). *The nation's report card: Mathematics 2011* (NCES 2012-458). Washington, DC: Institute of Education Sciences, U.S. Department of Education.

National Governors Association Center for Best Practices, Council of State School Officers. (2010). *Common core state standards in mathematics*. Washington, DC: Author. Retrieved from http://www.corestandards.org/

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.

Pashler, H., Bain, P., Bottge, B., Graesser, A., Koedinger, K., McDaniel, M., & Metcalfe, J. (2007). *Organizing instruction and study to improve student learning* (NCER 2007-2004). Washington, DC: U.S. Department of Education.

Powell, S. R., Fuchs, L. S., & Fuchs, D. (2013). Reaching the mountaintop: Addressing the common core standards in mathematics for students with mathematics difficulties. *Learning Disabilities Research & Practice*, *28*, 38–48. doi:10.1111/ldrp.12001

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models* (2nd ed.). Thousand Oaks, CA: SAGE.

Rittle-Johnson, B., Siegler, R. S., & Alibali, M. W. (2001). Developing conceptual understanding and procedural skill in mathematics: An iterative process. *Journal of Educational Psychology*, *93*, 346–362. doi:10.1037/0022-0663.93.2.346

Schoenfeld, A. H. (1989). Teaching mathematical thinking and problem solving. In L. B. Resnick & L. E. Klopfer (Eds.), *Toward the thinking curriculum: Current cognitive research* (pp. 83–103). Alexandria, VA: ASCD.

Scruggs, T. E., Mastropieri, M. A., & McDuffie, K. A. (2007). Co-teaching in inclusive classrooms: A meta-synthesis of qualitative research. *Exceptional Children*, *73*, 392–416.

Solis, M., Vaughn, S., Swanson, E., & Mcculley, L. (2012). Collaborative models of instruction: The empirical foundations of inclusion and co-teaching. *Psychology in the Schools*, *49*, 498–510. doi:10.1002/pits.21606

University of Iowa. (2008). *The Iowa Tests of Basic Skills (Form C)*. Itasca, IL: Riverside.

U.S. Department of Education, National Center for Education Statistics. (2007). *The condition of education 2007* (NCES 2007-064). Washington, DC: Government Printing Office.

VanDerHeyden, A., McLaughlin, T., Algina, J., & Snyder, P. (2012). Randomized evaluation of a supplemental grade-wide mathematics intervention. *American Educational Research Journal*, *49*, 1251–1284. doi:10.3102/0002831212462736

Vaughn, S., Schumm, J. S., & Arguelles, M. E. (1997). The ABCDEs of co-teaching. *TEACHING Exceptional Children*, *30*, 4–10.

Vukovic, R. K. (2012). Mathematics difficulty with and without reading difficulty: Findings and implications from a four-year longitudinal study. *Exceptional Children*, *78*, 280–300.

Wirkala, C., & Kuhn, D. (2011). Problem-based learning in K–12 education: Is it effective and how does it achieve its effects? *American Educational Research Journal*, *48*, 1157–1186. doi:10.3102/0002831211419491

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