

Grade-Aligned Math Instruction for Secondary Students with Moderate Intellectual Disability

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Abstract:

The purpose of this study was to examine the effects of grade-aligned math instruction on math skill acquisition of four middle schools with moderate intellectual disability. Teachers were trained to follow a task analysis to teach grade-aligned math to middle school students using adapted math problem stories and graphic organizers. The teacher implemented four math units representing four of the five National Council of Teachers of Mathematics recommended math standards (i.e., algebra, geometry, measurement, and data analysis/ probability; NCTM, 2002). A multiple probe across unit design was used to examine the effects of the math instruction on the number of steps completed on each math standard task analysis. Results indicated a functional relationship between math instruction and student behavior with an overall increase in independent correct responses. Implications for practice and future research are discussed. Limitations and suggestions for future research and practice are discussed.

Keywords: Special education | Mathematics instruction | Intellectual disabilities

Article:

One of the key concepts introduced in guidance for including students with disabilities in No Child Left Behind (2002) is that the target for some students with significant cognitive disability might be "alternate achievement" that is different in scope or complexity, but still aligned with grade level standards. Many states provide curricular frameworks or extensions for each grade's state standards to indicate how to access content like mathematics and English/language arts. To teach to the standards, instructional teams must still determine what the student will learn and how to teach it.

Although teachers have been required to help all students make adequate yearly progress, there have been few models for conducting standards-based instruction for students with moderate/severe intellectual disability especially in the area of mathematics. Textbooks on educating students with severe disabilities provide minimal information on teaching mathematics besides money and measurement (Ryndak & Alper, 1996, 2003; Snell & Brown, 2000, 2006; Westling & Fox, 2000, 2004). There also have been few research studies to guide these interventions. Browder, Spooner, Ahlgrim-Delzell, Wakeman, and Harris (2008) used guidelines from Horner et al. (2005) and Gersten et al. (2005) to identify high quality evidence-based mathematics research with students with a moderate/severe intellectual disability published between 1975 and 2005. Sixty-five articles yielded 54 single-case and 14 group studies (some articles had > 1 study). Although limited in scope, these studies provide evidence that this population can learn mathematics. A total of 493 individuals with disabilities participated in these studies including 336 individuals with moderate intellectual disability (mental retardation), 64 individuals with severe intellectual disability, 24 individuals with autism, 13 individuals with unspecified developmental disability, and one individual with multiple disabilities. These studies also indicate that interventions derived from principles of applied behavior analysis, such as systematic prompting with feedback, can be highly effective for teaching math content.

Browder et al. (2008) also found that most studies have focused on numbers and operations or money skills. These content areas are only a small sample of the recommended content for mathematics. In practice, teachers also typically focus on repetitive practice of computational skills, based on the belief that students master readiness skills before engaging in higher order math lessons (Woodward & Montague, 2002). With this focus, many students will not have access to the standards that will be included in states' alternate assessments based on academic achievement standards which must align to the content standards. Most states organize their standards by major strands of academic learning similar to, or the same as, those identified by the National Council of Teachers of Mathematics (NCTM). In 1989 and again in 2000, NCTM identified five main components of math instruction including (a) numbers and operations, (b) measurement, (c) data analysis and probability, (d) geometry, and (e) algebra. Most recently, the Common Core Standards in mathematics have defined a set of outcomes in these areas that are being adopted by most states in the United States.

One option for promoting learning across more content areas is to apply the practices used effectively in mathematics for students with moderate and severe intellectual disability across more state standards. Browder et al. (2008) identified one of these practices to be task analytic instruction with systematic prompting. In this review on mathematics, task analyses primarily were used to teach students to make a purchase from a store or vending machine (Aeschleman & Schladenauffen, 1984; Browder, Snell, & Wildonger, 1988; Haring, Kennedy, Adams, & Pitts-Conway, 1987). Two studies have applied task analytic instruction to teach grade-aligned state standards in mathematics. Jimenez, Browder, and Courtade (2008), used a multiple probe across participants design to demonstrate that three high school students with moderate intellectual

disability could learn to solve an algebraic equation. In addition, students were able to complete their problem solving in an inclusive high school general education setting beside peers who were working on similar equations and to generalize them across materials (i.e., job tasks). Browder et al. (2010) used a similar strategy to teach students multiple standards selected from the middle/secondary level. Students were randomly assigned to receive the standards-based instruction intervention in either mathematics or science in a pretest/posttest control group design. Students who received the mathematics intervention made higher gains on the curriculum-based math measure.

Although both of these studies provide promise for teaching middle or high school mathematics standards, Jimenez et al. (2008) only addressed one skill within one standard (solving a simple algebraic equation) and Browder et al. (2010) used a randomized trials design which provided evidence of group differences, but did not reveal whether all students mastered the content. One contribution that the Browder et al. study offered was that the mathematics problems were presented as real life problems that were read aloud to the students.

Literature on general mathematics instruction for middle school students suggests that skill development may be promoted by linking math and language arts (Zambo, 2005). Specifically, stories that are written within a context familiar to the student may provide a framework, or schema, upon which the student may naturally organize information in order to solve the problem (Anderson, Spiro, & Anderson, 1978). Pugalee (2005) developed a strategy for teaching mathematics with stories that build on research-based recommendations for teaching this content to students with learning disabilities. This approach includes (a) an advance organizer linking new information with prior learning, (b) walking through the story to model thinking about the math concept, (c) building skills by allowing the student the opportunity to practice applying new information, (d) generalization in which students develop stories or scenarios that embed this new information and (e) assessing students' performance.

Table 1. Student demographic information

Student	Age	Sex	IQ Score	Test administered	Classification	Communication
Claire	13	Female	40	WISC III	Moderate intellectual disability	Verbal
Kiernan	13	Male	40	WISC III	Moderate intellectual disability	Non-verbal, uses AC
Everett	13	Male	30-40	DAS	Sever intellectual disability	Non-verbal, Learning to use AC
Todd	11	Male	41	UNIT	Moderate intellectual disability	Verbal

Since students with moderate and severe intellectual disability may not read, teachers may need to follow a protocol for an interactive read-aloud. Browder, Trela, and Jimenez (2007) demonstrated how to promote active participation in literature adapted from middle and high school novels for students with moderate/severe intellectual disability or autism. In this approach, the story is introduced with some attention grabber (e.g., students may listen to whale calls in a story about the ocean). Then the teacher involves the student in the read-aloud, for example, by having the student complete repeated story lines or answer questions. Similarly, in a math story problem, the teacher can engage the student with the theme (e.g., sample donuts for a problem about how many donuts were purchased), have the students engage with the key math facts (e.g., finding each number), and then work together to find the solution.

The purpose of the current study was to extend the work on teaching upper level mathematics standards to students with moderate and severe intellectual disability through using read-alouds of math problems with task analytic instruction to find the solution. To promote generalization across math problems, graphic organizers were introduced to help students perform the steps of the problem solving. Although not often used in research with students with moderate/severe intellectual disability, graphic organizers have been found to promote comprehension of expository text for students with learning disabilities (Gajjria, Jitendra, Sood, & Sacks, 2007.) We theorize that the combination of a read-aloud of a math word problem, a graphic organizer, and task analytic instruction in the steps to solve the problem will be effective in promoting math learning for different types of standards for students with moderate and severe intellectual disability.

Method

Participants and Setting

The study was conducted in a large urban school system in the southeastern United States. The intervention was conducted by the special education teacher in a self-contained middle school classroom for students with moderate/severe intellectual disability. Participants were identified by recruiting a middle school special education teacher and asking her to nominate four students who met the following eligibility criteria (a) full scale IQ < 55, (b) adequate vision and hearing to interact with the materials, (c) an ability to communicate verbally or with an augmentative communication system, and (d) consistent attendance (absent less than two times per month). All students in the study participated in the state's large scale assessments by taking the alternate assessment based on alternate achievement standards for all content areas.

As shown in Table 1, students ranged in age from 11 to 13 and had IQs from 30-41. All IQ scores were obtained from students' most recent psychological evaluations. All assessments were conducted by a graduate level member of the research team in the special education classroom with the four target students. The teacher included other students in the instructional group

besides the target students and typically implemented the lesson with the entire class (8-10 students). Teacher trainings occurred in a university conference room.

Miguel has money to spend on things he can do in his leisure time.

He wants seeds to plant in his garden, a stopwatch to time his walks, and the new PlayStation Game.

First, he picks out some seeds.

What item will Miguel shop for next?

Geometry Unit
Department Store Site Map

Jewelry C.

D. Electronics

Garden B.

E. Magazine

A

Enter / Exit

Figure 1. Sample math story and graphic organizer for Geometry.

Materials

Instructional materials. Middle school mathematics standards were selected using the state's mathematics standards. These standards were simplified for instruction with the target population

and reviewed by a university level mathematics content expert to ensure that each target skill was aligned with the target standard. The research staff then created sets of word problems for each standard using the same problem solving method (e.g., solving an equation; comparing graphed data) but with different applications (e.g., shopping, dining out, voting) and differing numbers. Because of the students limited numeracy skills, the problems used numbers from 1-10. Each word problem was typed with key vocabulary (e.g., character in the word problem story) paired with pictures using a picture symbol software program (i.e., Writing with Symbols ©). Eight problems per math standard (i.e., algebra, data analysis, geometry, and measurement) were given to the teacher, with a total of 32 math stories provided. These adapted word problem stories were printed in color and placed in page protectors for durability. The teacher was provided a binder divided by each standard which was called a unit (e.g., Geometry Unit). Within each divided section of the binder, the teacher was provided the graphic organizer for that unit (standard) and the adapted stories that corresponded to the unit. The graphic organizers were printed in color and laminated for durability. Velcro was used to manipulate numbers on the graphic organizer if the student was not able to use a visa-vi marker to write numbers. Additional manipulatives were provided as necessary to complete the math lessons (e.g., paper money for measurement, green and red chips for the algebra prompt, nonpermanent markers for geometry). Teachers were also provided a poster size graphic organizer for each of the units to use for group instruction. Figure 1 shows a sample adapted story and graphic organizer from the geometry unit for which the standard focused on finding points, line segments, and points on a plane.

Dependent Variable

The dependent variable was the number correct math responses made by the student during the unit (e.g., algebra) assessment probe. To investigate changes in student behavior in response to teacher's use of the story-based math problems, four assessments of student responses were used (see Figure 2). The graduate assistant conducted one to two assessment probes with each student per week. A task analysis was created for the steps for each math standard (see Table 2). For each of the four math tasks, task analytic assessments were developed (Browder, Spooner, & Jimenez, 2011). During each of the assessments, the researcher displayed the needed materials and posed a question for the student to solve (e.g., "Show me how to_ (find point A).") The student was given five seconds to begin each step of the task analysis. If the student did not complete a step, the researcher completed the step and said, "Keep going." Students received praise for paying attention and working on the tasks. No task specific prompts or feedback were given. Each step of the task analysis was scored as correct (+) or incorrect (-). For generalization, students were probed on math problem stories that had not been used during instruction, but required the same mathematical problem solving skill (e.g., steps to solve an equation.)

Experimental Design and Analysis

A single subject design was used to demonstrate a functional relationship between the mathematics intervention and the dependent variable which was acquisition of math responses.

Specifically, the design was a multiple probe across four math units (standards) with concurrent between participant replications for the four target participants who received instruction as a group (Gast, 2010; Horner & Baer, 1978). During baseline, the math responses were probed for each student at minimum of three sessions or until data was consistent for three sessions. Following baseline, instruction began on Unit 1 (i.e., Geometry standard) for all four students. Students received task-analytic math lessons by the special education teacher. Prior to the students moving from Unit 1 to Unit 2 (i.e., Algebra), all individual students' data had to show a change or trend after receiving instruction for a minimum of 5 weeks instruction on that unit. Once the students were ready to move to Unit 2, the students were each probed on Unit 2, Unit 3, and Unit 4 responses. After students' data for Unit 2 showed a change in level or trend after receiving a minimum of five weeks instruction, Unit 3 (i.e., Data-Analysis) and Unit 4 (i.e., Measurement) were probed. Unit 3 was then taught following the same guidelines for Units 1 and 2, before Unit 4 was introduced. Prior to Unit 4 being taught, Unit 4 was probed. Instruction continued for a minimum of five weeks and until all student data showed a change in level and trend. Maintenance probes (units 1-3) of previous units were conducted every two to three weeks after intervention throughout the duration of the study. No maintenance of Unit 4 was taken due to the ending of the school year. Only independent correct student responses were graphed and used for visual analysis of the data.

Geometry Test				
Objective	Materials	Direction : <i>Mark incorrect if no answer within 5 seconds</i>	Correct Student Response	Score: 0=no, incorrect response 1= correct response
1. Identify point on a map.	Map of store with points labeled	Find point A	Points to Point A on map	0 1
2. Identify point on a map	Map of store with points labeled	Find point P	Points to Point P on map	0 1
3. Draws, places stick to draw line from point to point	Map of store with points labeled, stick or straw	Draw line segment AP	Draws line AP; Places straw or stick between points A and P	0 1
4. Identify point on a map	Map of store with points labeled	Find point D	Points to Point D on map	0 1
5. Draws, places stick to draw line from point to point	Map of store with points labeled, stick or straw	Draw line segment PD	Draws line PD; Places straw or stick between points P and D	0 1
6 Identify point on a map	Map of store with points labeled	Find point E	Points to Point E on map	0 1
7. Draws, places stick to draw line from point to point	Map of store with points labeled, stick or straw	Draw line segment DE	Draws line DE; Places straw or stick between points D and E	0 1
8. Draws, places stick to draw line from point to point	Map of store with points labeled, stick or straw	Draw line segment EA	Draws line EA; Places straw or stick between points E and A	0 1
9. Identifies plane on map	Map of store with points labeled, lines drawn or placed; AT with correct choice, 2 distracters & pictures	What is this called?	Says, uses AT to say "plane"	0 1

Date: _____

Score: _____

School: _____ Teacher: _____ Student: _____

Examiner: _____ IRR Observer: _____ IRR Score: _____

Figure 2. Sample Student Assessment in Geometry.

Procedure

Baseline and Ongoing Probes. During baseline, the graduate research assistant served as the primary data collector. Inter-observer agreement was taken on one of the three baseline sessions by a second member of the research team. Students were individually assessed for each of the four units of instruction during each baseline probe. All baseline probes followed the same guidelines described under the description of the dependent variable. No feedback was given to students during baseline probes. Data was graphed and visually inspected after each session. After baseline, the same procedures were followed to continue to probe whatever unit was receiving instruction. That is, one or two times a week prior to the lesson, the graduate student conducted the task analytic assessment for that unit. At the end of a unit, all units were reprobbed before the next was introduced.

Table 2. Content Standards, Alternate Achievement, and Task Analyses Used in Math

National Standard (NCTM_ based on 6-8 th grade bands Competency Goal(s) from state standard course of study standards	Competency Goal(s) from state standard course of study standards	Alternate Achievement standards addressed on this study	Task Analysis
Algebra: Represent and analyze mathematical situations and structures using algebraic symbols.	Use and evaluate algebraic expressions. Solve simple (one- and two-step) structures using equations or inequalities. algebraic symbols.	Solve simple one-step equations that relate to stories about daily events.	Identify problem statement. Identify first, second, and last fact in story. Name unknown quantity "x". Place facts in correct sequence on Equation Prompt. Identify operation needed to solve problem. State solution to problem. State solution in story context.
Geometry: Specify locations and describe spatial relationships using coordinate geometry and other representational systems. Use visualization, spatial reasoning, and geometric modeling to solve problems.	Represent problem situations with geometric models. Identify, predict, and describe dilations in the coordinate plane.	Identify and describe the intersection of figures in a plane. Draw line segments and a coordinate plane to demonstrate spatial sense for familiar contexts like grocery store.	Identify problem statement. Identify points on a map using facts from story. Draw line segments. State solution to problem. State solution in story context.
Measurement: Apply appropriate techniques, tools, and formulas to determine measurements.	Develop flexibility in solving problems by selecting strategies and using mental computation, measurements. estimation, calculators or computers, and paper and pencil.	Develop numbers sense. Identify problem statement. for real numbers. Develop flexibility in solving mathematical equal problems by selecting strategies and using appropriate technology. Use next dollar strategy	Identify dollar amount from fact in story. Count number of one dollar bills to given dollar amount. Count out one more dollar, (if verbal, may say "and one more" while counting one more). State solution to problem. State solution to in story

		related to everyday transactions.	context. solve problems
Data Analysis and Probability: Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	Collect, organize, analyze, and display data (including box plots and histograms) to solve problems.	Collect, organize and display data to solve problems from familiar events.	Identify problem statement. Record data from story on graph. Identify choice with "more".state solution to problem. State solution in story context.

Intervention

The mathematics intervention included (a) mathematics word problem stories based on familiar activities, (b) a graphic organizer and manipulatives for the mathematics concept (e.g., a template for solving the linear equation), and (c) step by step training in the task analysis to identify and organize key facts and solve the problem stated in the written story. The special education teacher participated in four professional development workshops. A general education mathematics teacher from the teacher's middle school also attended the training and served as an ongoing resource person for understanding the mathematics content. Three of the four workshops involved training on the mathematics intervention and the fourth served as a debriefing for the study. In the first two workshops, the teacher received training in the first two units (algebra and geometry); in the third workshop two units were trained (data analysis and measurement.)

During each workshop, the research team provided an introduction to the "big idea" of the unit (e.g., geometry addressed spatial organization and vocabulary related to coordinate planes) and a review of current research in teaching mathematics to support special educators' understanding of the mathematics standard. The general mathematics teacher was asked to provide examples of how this standard was typically taught. The researcher modeled one lesson, and then the special education teacher was given an opportunity to practice implementing the lesson with feedback until the read-aloud, use of the graphic organizer, and task-analytic instruction could be presented without error. Although the math and special education teachers also practiced planning inclusive co-taught math lessons, these were not implemented during the course of the study due to logistics of the setting.

Following each of the first three professional development workshops, the special education teacher implemented the lessons in the special education classrooms with the target students in a group format. The teacher adapted the materials for any students' individual needs (e.g., poster size version of the number line in algebra, use of popsicle sticks to draw line segments in geometry). During each lesson, the teacher read the word problem story aloud as students followed using their copies of the story. Then, each student was given the opportunity to perform each step of the task analysis while the other students in the group watched. The teacher used least intrusive prompting as needed for the student to make each target response (non-specific

verbal direction, specific verbal direction, model, and physical guidance) and provided praise for each correct response. The teacher varied the order of student responding each day. Materials contained a variety of stories so that the problem to be solved and specific numbers to compute varied while keeping the basic math strategy (e.g., use of a bar graph) constant. The teacher continued instruction, adding her own stories as needed, until the next unit was introduced. The researcher observed the teacher to assess procedural fidelity by observing whether each step of the task analysis was presented correctly. A procedural fidelity checklist was also used for the teacher training days to be sure the researchers included the overview, model, and teacher practice. A graduate assistant who was not an author recorded these data.

Results

Procedural Fidelity

Procedural fidelity was recorded for all four math workshops and found to be 100%. The special education teacher was observed eleven times (i.e., two to three times for each unit) to assess fidelity of teaching the task analyses. Procedural fidelity was computed as percentage of steps taught correctly. The teacher implemented the lesson plans with 100% fidelity for all lessons observed. Two researchers concurrently scored fidelity of the lessons for 36% (four) of the observations. Agreement between the observers was 100%.

Inter-rater Reliability

The primary data collector was a graduate research assistant who was a special education doctoral student. Independent scoring by two observers was performed on 40% of all assessment probes administered. Interobserver agreement was computed as agreements divided by agreements plus disagreements. The percent agreement was 99% and adherence to the task analytic assessment protocol was 100% for all sessions observed. Figures 3-6 provide the total number of correct responses across each of the four math units. Within each unit of instruction skill maintenance is reported.

Claire. During unit 1: geometry, Claire increased the number of independent correct responses from baseline ($M = 1.3$, range from 1 to 2) to intervention ($M = 5.1$, range from 3 to 7). During unit 2: algebra, Claire increased in the total number of correct responses from baseline ($M = 3$, range from 0 to 5) to intervention ($M = 3.9$, range from 0 to 7). During unit 3: data-analysis, Claire increased in the total number of correct responses from baseline ($M = .6$, range from 0 to 1) to intervention ($M = 4.3$, range from 2 to 7). Finally, during unit 4: measurement, Claire increased in the total number of correct responses from baseline ($M = .33$, range from 0 to 1) to intervention ($M = 2$, range from 0 to 6, see Figure 3).

Kiernan. During unit 1: geometry, Kiernan increased the number of independent correct responses from baseline ($M = 1$) to intervention ($M = 6$, range from 3 to 9). During unit 2: algebra, Kiernan increased in the total number of correct responses from baseline ($M = 1.7$, range

from 1 to 3) to intervention ($M = 6.3$, range from 1 to 10). During unit 3: data-analysis, Kiernan increased in the total number of correct responses from baseline ($M = .6$, range from 0 to 1) to intervention ($M = 4.3$, range from 2 to 7). Finally, during unit 4: measurement, Kiernan increased in the total number the number of correct responses from baseline ($M = .5$, range from 0 to 1) to intervention ($M = 2.6$, range from 0 to 4, see Figure 4).

Everett. During unit 1: geometry, Everett increased the number of independent correct responses from baseline ($M = .33$, range from 0 to 1) to intervention ($M = 1.7$, range from 0 to 3). During unit 2: algebra, Everett increased in the total number of correct responses from baseline ($M = 1$, range from 0 to 3) to intervention ($M = 4.7$, range from 1 to 7). During unit 3: data-analysis, Everett increased in the total number of correct responses from baseline ($M = .2$, range from 0 to 1) to intervention ($M = 2.7$, range from 0 to 5). Finally, during unit 4: measurement, Everett increased in the total number of correct responses from baseline ($M = 0$) to intervention ($M = 1.4$, range from 0 to 2, see Figure 5).

Todd. During unit 1: geometry, Todd increased the number of independent correct responses from baseline ($M = 4$) to intervention ($M = 7.4$, range from 3 to 9). During unit 2: algebra, Todd increased in the total number of correct responses from baseline ($M = 4$, range from 2 to 5) to intervention ($M = 7.6$, range from 4 to 10). During unit 3: data analysis, Todd increased in the total number of correct responses from baseline ($M = .8$, range from 0 to 2) to intervention ($M = 7.3$, range from 5 to 9). Finally, during unit 4: measurement, Todd increased in the total number of correct responses from baseline ($M = .6$, range from 0 to 2) to intervention ($M = 9.3$, range from 7 to 10, see Figure 6).

Table 3 indicates the mean number of correct responses students had from baseline to intervention across each unit of math instruction. Data for generalization of math skills are also reported in Table 3. All students had higher mean responses during intervention, maintained most steps of the math task analysis over time (e.g., geometry-18 weeks), and generalized the skills to untaught problems.

Social Validity

At the final workshop, the teacher was asked to complete an adapted intervention rating profile (Snyder, 2002) to indicate level of satisfaction with the training and instructional materials. The teacher responded to seven items about the intervention using a six-point Likert scale (i.e., 1 = strongly disagree; 6 = strongly agree). The teacher agreed or strongly agreed with all items (mean of 5.75) that the math lesson plan trainings were helpful on clarifying how to write lesson plans that access the general curriculum in secondary grades. She felt that the lesson plans were practical and strengthened her skills as a teacher.

Discussion

This study demonstrated that not only can students with moderate and severe intellectual disability learn new math skills aligned to grade-level content, they can learn new math skills across the math standards (e.g., algebra, geometry). This adds to the work of Browder et al. (2010) showing that a method of standards-based instruction that can be applied across different standards. Like Browder et al. this study used read-alouds of word problems, a graphic organizer, and task analytic instruction in how to solve the problem. This study adds to the earlier study by demonstrating that each of four students made gains on each mathematical standard.

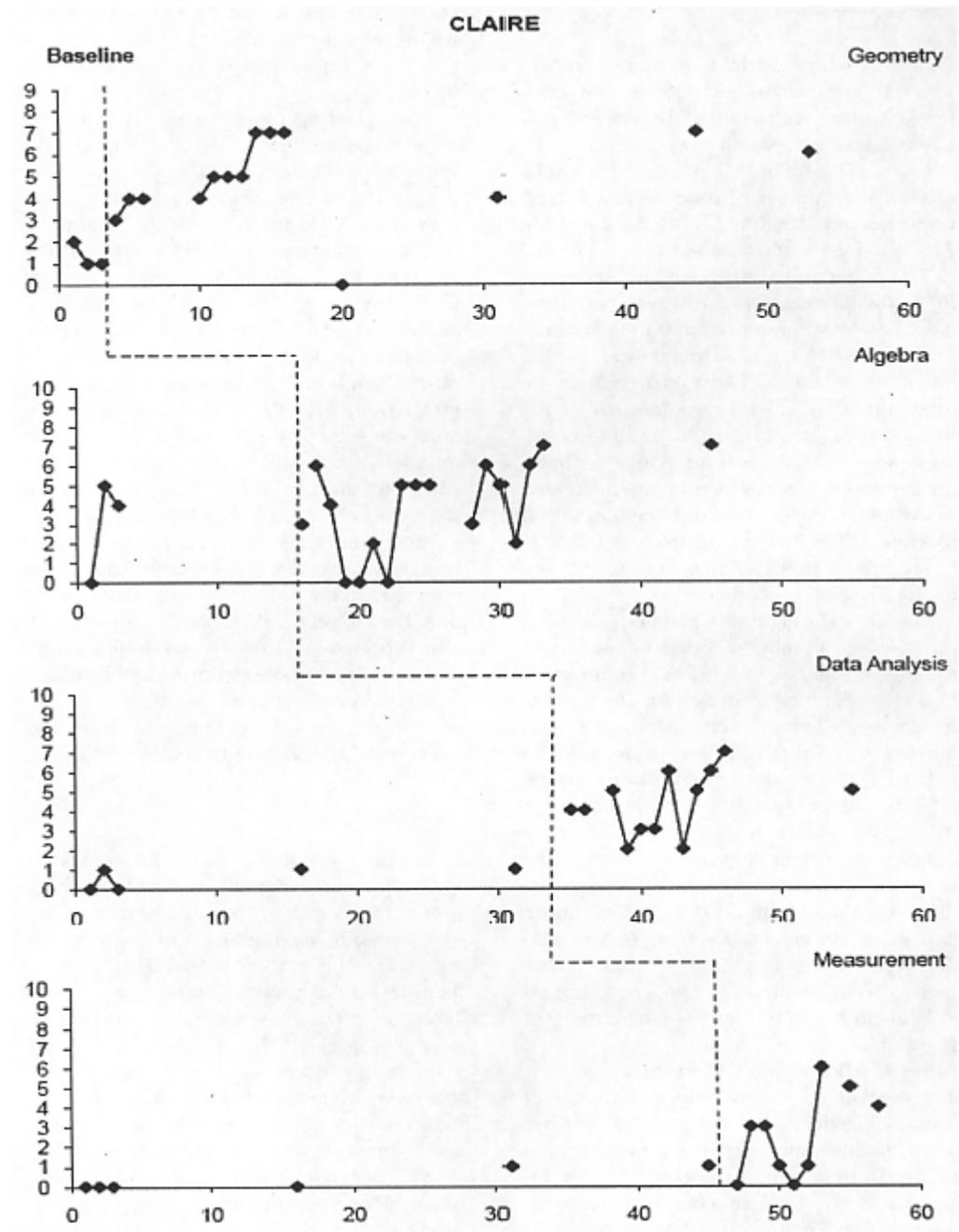


Figure 3. Student data across math units for Claire.

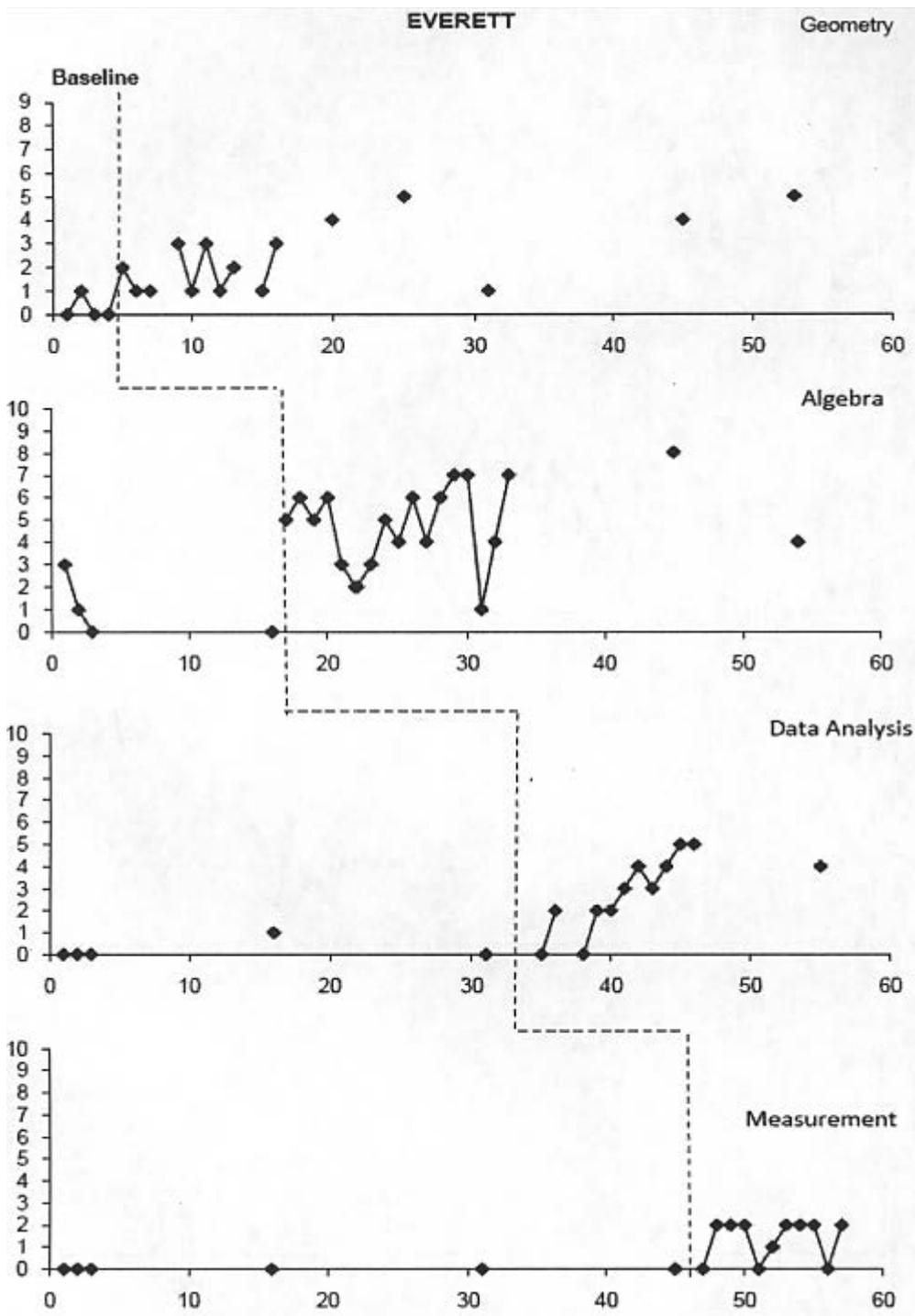


Figure 4. Student data across math units for Everett.

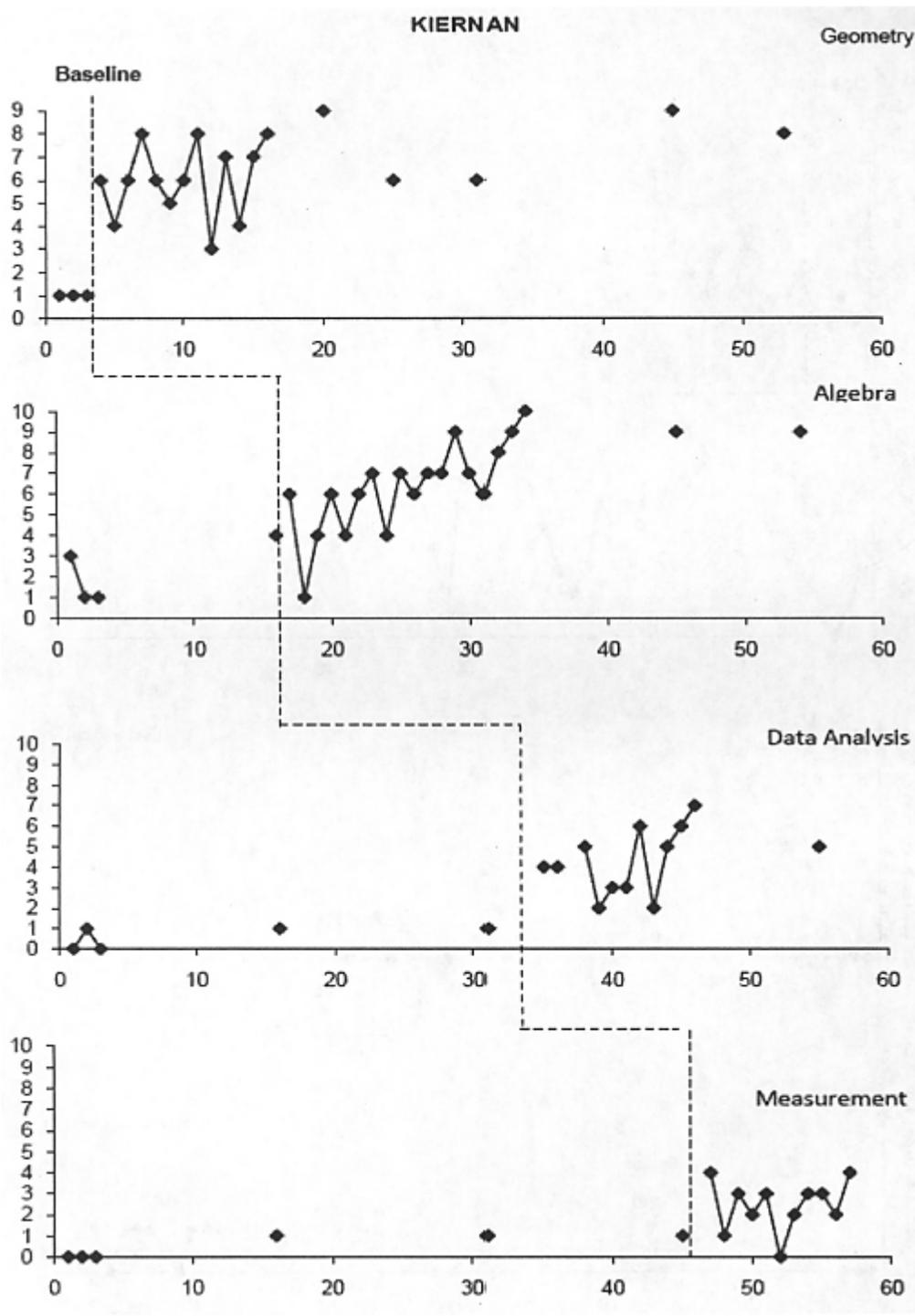


Figure 5. Student data across math units for Kiernan.

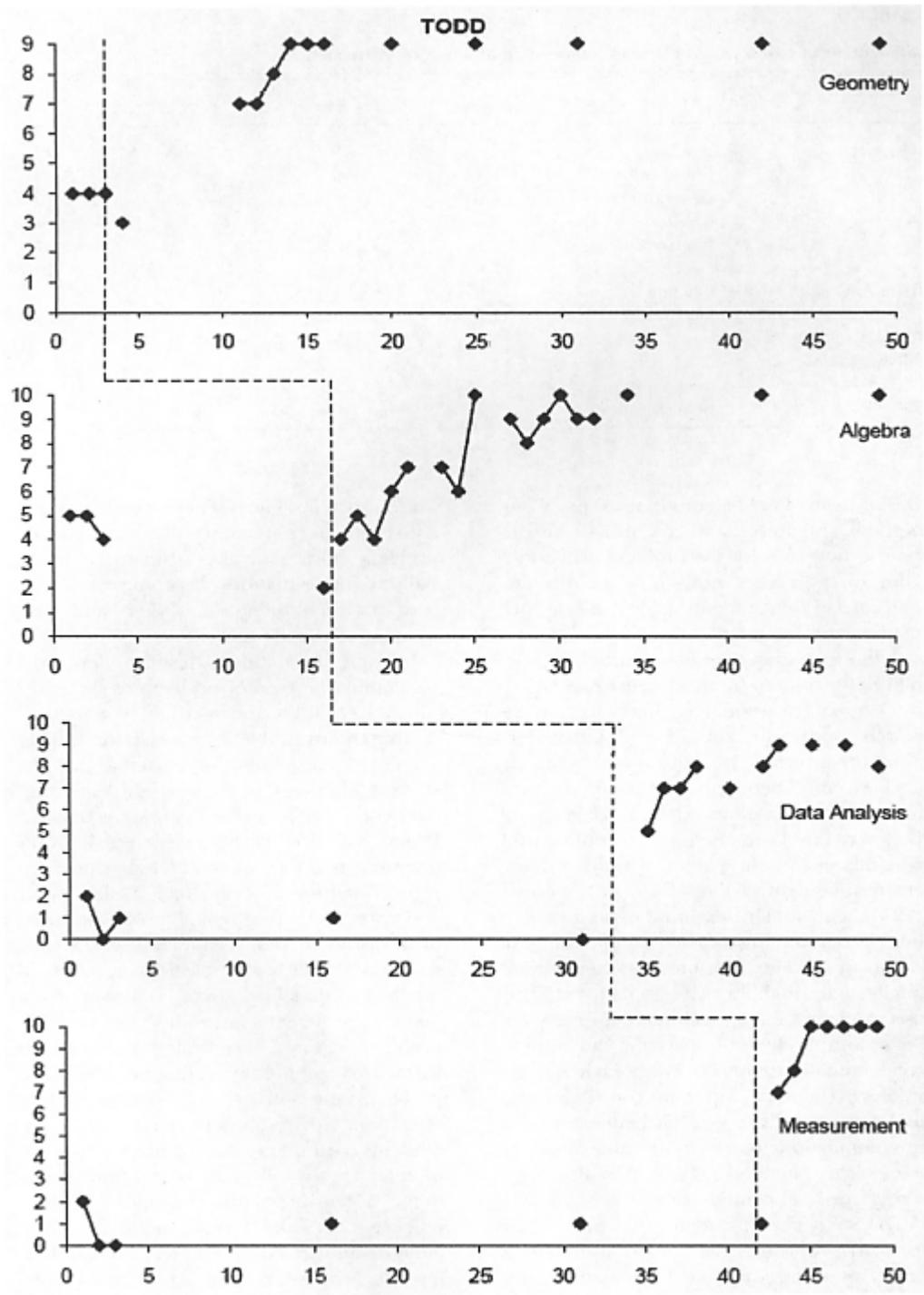


Figure 6. Student data across math units for Todd.

Table 3. Student mean scores across phase of intervention and unit of instruction

		Kiernan	Reese	Everett	Claire
Geometry	Baseline	1.3	1	.33	4
	Intervention	5.1	6	1.7	7.4
	Generalization	4.6	7.6	3.8	9
Algebra	Baseline	3	1.7	1	4
	Intervention	7.1	6.3	4.7	7.6
	Generalization	7	9	6	10
Measurement	Baseline	.33	.5	0	.6
	Intervention	2	2.6	1.4	9.3
	Generalization	4.5	n/a	n/a	n/a

Although standards-based instruction is required for students to meet state expectations on alternate assessments, there are few research models for this type of instruction. Since the Browder et al. 2008 review, researchers have continued to focus teaching purchasing and computations. Collins, Hager, and Galloway (2011) focused on computation of sales-tax, but within general education mathematical content. Skibo, Mims, and Spooner (2011) used student response cards and least intrusive prompting to teach number identification to students with moderate and severe intellectual disability. Zisimopoulos (2010) used a picture fading technique to teach students with moderate intellectual disability to recall multiplication facts. While each of these studies provides an important contribution to understanding how to teach mathematics to this population, the current study provides evidence of a method to teach skills that align with grade-level content standards.

This study taught students how to respond word problems. The NCTM promotes a problem-solving approach to mathematics (2000). Van de Walle (2004) proposes that learning to solve story problems in mathematics is the basis for learning to solve more real world problems. Fuchs, Fuchs, Finelli, Courey, and Hamlett (2004) note that mathematical problem solving involves students applying skills to novel situations. Teaching word problems can teach students the "when" and "why" to apply mathematical skills.

In contrast, we did not teach students how to identify the type of problem to be solved which is typically the focus of research on teaching word problems. Instead, the teacher presented the graphic organizer to cue the student what type of problem this was (e.g., data comparison versus algebraic equation.) Browder et al.'s (2008) review revealed only one study that focused on teaching students a problem-solving schema. Neef, Nelles, Iwata, and Page (2003) taught math problem solving to one student with a moderate intellectual disability (i.e., a second participant had mild intellectual disability). Neef et al. taught students "precurrent operations" to facilitate problem solving. Specifically, the students learned to identify five components of word problems: the initial set, the change set, the operation, the result set, and the solution. Students used a graphic organizer worksheet to enter known information and find the solution.

The intervention included massed practice trials with a teacher model. Both students demonstrated generalized problem solving. Much more research is needed to determine how best to teach this population to recognize the type of problem presented in the math story.

A second limitation of the current study is that while all students made gains, the gains in the measurement unit were minimal for three of the four students. This may have been an artifact of the specific task analysis on counting the next dollar amount. While the other task analyses only required the students to solve one problem, because the next dollar task analysis was short, students solved three problems and the data were added together. If the student could not perform some steps, this would occur all three times. Students may also have been less motivated to repeat these responses three times with no reinforcement for correct responding.

A third limitation is that while the stories were focused on real life math applications (e.g., going to the movies, shopping), the teacher did not assess generalization to these contexts. The students did show generalization to untrained story problems. It is unknown whether they also would have generalized these to community contexts. While the teacher did use some generalization activities (e.g., voting to practice data compilation), no data were collected.

Implication for Practice and Future Research

This study provided evidence to support that students with moderate and severe intellectual disability can learn middle school mathematics standards with a read-aloud of word problems, task analytic instruction to solve the problem, and graphic organizer. The stories used helped focus the instruction on real life applications that are important to make the standards-based instruction meaningful (e.g., going to the movies.) In replicating these lessons with students, educators should consider stories that apply to students' local environments (e.g., story on Charlotte Speedway would not be relevant in some contexts.) The graphic organizers may also need to be modified for students' visual or physical limitations. For example, the teacher found some students responded better if the graphic organizer was enlarged to poster size.

Future research is needed to determine if this strategy may be applicable to standards in other grade levels (e.g., elementary or high school), to students with other types of disabilities, and to other state standards. Research also is needed to determine if this method is the most effective for repetitive skills like counting money since this produced the lowest gains. Additionally, research evidence is needed to determine if this read-aloud problem solving strategy could be embedded in a general education context. For example, could peers conduct the read-aloud? Finally, research also is needed on how students generalize the acquisition of mathematics standards to everyday activities.

References

Aeschleman, S. R., & Schladenauffen, A. F. (1984) . Concept learning by retarded children: A comparison of three discrimination learning procedures. *Journal of Mental Deficiency Research*, 26, 229-238.

Anderson, R. C., Spiro, R. J., & Anderson, M. C. (1978). Schemata as scaffolding for the representation of information in connected discourse. *American Educational Research Journal* 15, 433-440.

Browder, D. M., Snell, M. E., & Wildonger, B. (1988). Simulation and community-based instruction of vending machines with time delay. *Education and Training in Mental Retardation*, 23, 175-185.

Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Wakeman, S. Y., & Harris, A. (2008). A meta-analysis on teaching mathematics to students with significant cognitive disabilities. *Exceptional Children*, 74, 407-432.

Browder, D. M., Spooner, F., & Jimenez, K. (2011) . *Standards-based individualized education plans and progress monitoring*. In D. Browder & F. Spooner (Eds.), *Teaching students with moderate and severe disabilities* (pp. 168-200). New York, NY: Guilford Press.

Browder, D. M., Trela, K., Courtade, G. R., Jimenez, B. A., Knight, V., & Flowers, C. (2010) . Teaching mathematics and science standards to students with moderate and severe developmental disabilities. *The Journal of Special Education*. Advance online publication. doi:10.1177 /0022466910369942

Browder, D. M., Trela, K., & Jimenez, B. (2007). Training teachers to follow a task analysis to engage middle school students with moderate and severe developmental disabilities in grade-appropriate literature. *Focus on Autism and Other Developmental Disabilities*, 22, 206-219.

Collins, B. C., Hager, K. L., & Galloway, C. C. (2011). Addition of functional content during core content instruction with students with moderate disabilities. *Education and Training in Autism and Developmental Disabilities*, 46, 22-39.

Fuchs, L. S., Fuchs, D., Finelli, R., Courey, S. J., & Hamlett, C. L. (2004) . Expanding schema-based transfer instruction to help third graders solve real-life mathematical problems. *American Educational Research Journal* 41, 419-445. doi: 10.3102/00028312041002419

GaJjria, M., Jitendra, A. K., Sood, S., & Sacks, G. (2007) . Improving comprehension of expository text in students with LD: A research synthesis. *Journal of Learning Disabilities*, 40, 210-225.

Cast, D. L. (2010) . *Single-subject research in behavioral sciences*. New York, NY: Routledge.

Gersten, R., Fuchs, L., Compton, D., Coyne, M., Greenwood, C., & Innocenti, M. S. (2005). Quality indicators for group experimental and quasi-experimental research in special education. *Exceptional Children, 71*, 149-164.

Haring, T. G., Kennedy, G. H., Adams, M. J., & Pitts-Conway, V. (1987). Teaching generalization of purchasing skills across community settings to autistic youth using videotape modeling. *Journal of Applied Behavior Analysis, 20*, 89-96.

Homer, R. D., & Baer, D. M. (1978). Multiple-probe technique: A variation of the multiple baseline. *Journal of Applied Behavior Analysis, 11*, 189-196.

Homer, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single subject research to identify evidence-based practice in special education. *Exceptional Children, 71*, 165-180.

Jimenez, B. A., Browder, D. M., & Courtade, G. (2008). Teaching an algebraic equation to high school students with moderate developmental disabilities. *Education and Training in Developmental Disabilities, 43*, 266-274.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards school mathematics*. Reston, VA: Author. National Council of Teachers of Mathematics (NCTM; 2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Neef, N. A., Nelles, D. E., Iwata, B. A., & Page, T. P. (2003). Analysis of precurent skills in solving mathematics story problems. *Journal of Applied Behavior Analysis, 36*, 21-33.

No Child Left Behind Act of 2001, Pub. L. No. 107-110, 115, § 1425, 20 U.S.C. §§ 6301 *et seq.* (2002).

Pugalee, D. K. (2005). *Writing for mathematical understanding*. Norwood, MA: Christopher Gordon Publishers.

Ryndak, D. L., & Alper, S. (1996). *Curriculum content for students with moderate and severe disabilities in inclusive settings*. Boston, MA: Allyn & Bacon.

Ryndak, D., & Alper, S. (2003). The curriculum content and identification process: Rationale and overview. *Curriculum and instruction for students with significant disabilities in inclusive settings* (pp. 1-112). Boston, MA: Allyn & Bacon.

Skibo, H., Mims, P., & Spooner, F. (2011). Teaching number identification to students with severe disabilities using response cards. *Education and Training in Autism and Developmental Disabilities, 46*, 124-133.

Snell, M. E., & Brown, F. (Eds.). (2000). *Instruction of students with severe disabilities* (5th ed.). Upper Saddle River, NJ: Merrill.

Snell, M. E., & Brown, F. (Eds.). (2006) . *Instruction of students with severe disabilities* (6th ed.). Columbus, OH: Merrill.

Snyder, E. P. (2002). Teaching students with combined behavioral disorders and mental retardation to lead their own IEP meetings. *Behavioral Disorders*, 27, 340-357.

Van de Walle, J. A. (2004) . *Elementary and middle school mathematics: Teaching developmentally* (5th ed.) . Boston, MA: Allyn & Bacon.

Westling, D. L., & Fox, L. (2000) . *Teaching students with severe disabilities* (2nd ed.). Englewood Cliffs, NJ: Merrill.

Westling, D. L., & Fox, L. (2004). *Teaching students with severe disabilities* (3rd ed.). Upper Saddle River, NJ: Merrill.

Woodward, J., & Montague, M. (2002). Meeting the challenge of mathematics reform for students with LD. *The Journal of Special Education*, 36, 89-101.

Zambo, R. (2005) . The power of two: Linking mathematics and literature. *Mathematics Teaching in Middle School* 10, 394-399.

Zisimopoulos, D. A. (2010). Enhancing multiplication performance in students with moderate intellectual disabilities using pegword mnemonics paired with a picture fading technique. *Journal of Behavioral Education*, 19, 117-133.