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Contextualizing Mathematics: Teaching Problem Solving to Secondary Students With Intellectual and Developmental Disabilities

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Abstract

The purpose of this study was to evaluate the effect of a multicomponent mathematics intervention (modified schema-based instruction, video anchors, and goal setting with self-graphing) on mathematical problem-solving skills of secondary students with intellectual and developmental disabilities. Three participants were taught to solve percent of change word problems, which involved calculating the discounted price of an item or activity after using a coupon and then determining whether they had enough money to make the purchase. Results of the multiple probe across participant design indicate a functional relation between the intervention and problem solving, and all participants were able to generalize skills from word problems to real-world stimuli (i.e., coupons, receipts, menus). Implications for practice and future research are discussed.

Key Words: *mathematics; generalization; general curriculum access; problem solving*

Prior debates surrounding curricular content and priorities for students with intellectual disability and related developmental disabilities (IDD) have presented a dichotomous relationship between functional and academic skills, where "functional skills" were narrowly defined, particularly in the area of mathematics (Saunders, Root, & Jimenez, 2018). This exclusive emphasis was reflected in the seminal meta-analysis conducted by Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008) of mathematics interventions for students with significant cognitive disability published between 1975-2005, as the vast majority focused on basic skills such as money, time, and counting. The emphasis on "functional skills" for people with IDD originated from Brown, Nietupski, and Hamre-Nieutupski's (1976) criterion of ultimate functioning, which called for maximizing instructional time through a focus on skills that would be used later in their lives.

Educators and researchers alike have spent more than a decade grappling with ways to provide instruction that meets the multifaceted needs of individuals with IDD, including both the formal academic curriculum and informal, individualized curriculum (Thompson, Shogren, & Wehmeyer, 2017). Although these have been seen as competing priorities in the past (e.g., Agran, Alper, & Wehmeyer, 2002), instruction on prioritized and personally relevant academic skills can complement goals in other areas (Trela & Jimenez, 2013). There is growing consensus that increased academic instruction provided to people with IDD will correspond with increased opportunities over prior generations (Spooner & Browder, 2015; Taber-Doughty, 2015).

Although the learning characteristics of students with IDD have not decreased in complexity, the cultural expectations and opportunities have increased (Spooner & Browder, 2015). The recent *Endrew v. Douglas County School District* (2017) Supreme Court decision emphasizes IDEA's mandate for individualized education plans to be appropriately ambitious with challenging objectives, and for educators to utilize scientifically based research supporting instructional practices. Furthermore, engagement in college and postsecondary education opportunities for young adults with IDD are rapidly expanding as a result of the Higher Education Opportunities Act (P.L. 110-315; Newman, Wagner, Cameto, Knokey, & Shaver, 2010). To quantify the impact of the past decade of legislative reforms, Spooner, Root, Saunders, and Browder (2018) examined the body of research on teaching mathematics to students with moderate and severe developmental disability published since Browder et al.'s (2008) analysis. Spooner and colleagues found a shift in emphasis from basic skills and traditionally "functional" mathematics (e.g., counting coins, next dollar strategy, number identification) toward chronologically age-appropriate and grade-aligned skills (e.g., solving equations, interpretation of graphical data). Five evidence-based practices were identified (i.e., explicit instruction, systematic instruction, technology-aided instruction, graphic organizers, manipulatives), contributing to the body of sound instructional practices educators and researchers can draw on to provide instruction to this population.

High-quality mathematics instruction not only teaches students *how* and *what* to do, but *when* and *why* to apply mathematical skills (Browder et al., 2018). Findings from Kearns, Towles-Reeves, Kleinert, Kleinert, and Thomas (2011) indicate mathematics is a significant area of need, as only 4% of students in a national sample from five states who took alternate assessments aligned with alternate achievement standards (AA-AAS) were able to apply computational procedures to solve real-world problems aligned to grade-level standards. We propose that a shift in focus from functional mathematics instruction to contextualized mathematics instruction may promote the acquisition and generalization of skills across contexts and ensure that students with IDD have a personally relevant curriculum (Trela & Jimenez, 2013). Contextualized instruction focuses on the development of an academic concept within a real-life activity or natural routine, as opposed to placing the emphasis on completing a task and teaching the associated academic skills to accomplish the goal in the traditional functional academics model (Saunders, Browder, & Root, 2017).

Strategies for Providing Contextualized Instruction

Contextualized instruction is not synonymous with community-based instruction. There are multiple ways to contextualize a targeted mathematics skill within its real-world application that can be achieved within a school setting. For mathematics, using a contextualized approach may promote generalization to natural contexts more systematically by training sufficient exemplars (Stokes & Baer, 1977). Recent research provides several strategies for providing contextualized instruction to teach mathematics skills to secondary students with IDD, including using natural stimuli, videos, and thematic word problems. Collins, Hager, and Galloway (2011) taught middle school students with moderate levels of intellectual disability to use a calculator to compute sales tax for items in newspaper ads. The prioritized middle grades mathematics skill was order of operations, but researchers applied it to a personally relevant context and used concrete realia (i.e., newspaper ads). As a result, participants were able to generalize skills to novel instructional materials.

Videos can also be used to provide a context for mathematics instruction to increase the personal relevance of prioritized skills. For example, Creech-Galloway, Collins, Knight, and Bausch (2013) used videos of real-world applications (i.e., quilting) to anchor instruction on the Pythagorean theorem with high school students with moderate levels of ID. Similarly, Saunders, Spooner, and Ley Davis (2018) taught three middle school students with moderate levels of ID to solve video-simulation problems of real-world mathematical scenarios requiring addition and subtraction (i.e., shopping, yard chores). Videos can provide multiple exemplars and reduce irrelevant stimuli that may otherwise be distracting (Ayres, Langone, Boon, & Norman, 2006; Stokes & Baer, 1977). Additional benefits of video-based instructional methods include cost-effectiveness and practicality, as they provide opportunities for repeated viewing and increased time efficiency over in-vivo community-based instruction (Mechling, 2011). Simulations provided through video-based instruction offer ways to build generalization by simulating real-world, naturally occurring situations.

Thematic word problems can also be used to facilitate a contextualized approach to mathematics. Modified schema-based instruction (MSBI) is a strategy for teaching students to solve thematic word problems by adding evidence-based instructional supports for teaching mathematics to learners with IDD (e.g., task analysis, systematic prompting and fading, visual supports) to traditional schema-based instruction (SBI). Traditional SBI is an evidence-based practice for students with high incidence disabilities (Jitendra et al.,

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2015). Explicit instruction is used to teach students to identify the underlying problem structure, represent the problem with a schematic diagram (graphic organizer), follow a heuristic to solve the problem, and check their work (Jitendra et al., 2015). The conceptual model for MSBI by Spooner, Saunders, Root, and Brosh (2017) adds four components to traditional SBI: (a) ensure access to problems through problem development and read-aloud assistance; (b) teach conceptual understanding through provided enhanced visual supports (i.e., color-coded graphic organizers); (c) support procedural knowledge by using systematic and explicit instruction through steps of student-friendly task analysis as a heuristic; and (d) build generalization.

Teaching Personal Finance Skills Through Contextualized Instruction

Personal finance tasks provide a natural context for instruction on complex mathematical skills. For example, Root, Saunders, Spooner, and Brosh (2017) taught middle school students with moderate levels of ID how to calculate the final price when leaving a tip or purchasing an item on sale through MSBI. Participants were provided with word problems that depicted a variety of real-world scenarios of leaving a tip or purchasing activities/ items on sale (i.e., car wash, hotel, florist), and were taught how to use a calculator and graphic organizer to find the total cost. Bouck, Satsangi, and Bartlett (2016) pointed out the complexity of skills required for budgeting and being a savvy consumer, which go beyond calculations to require reasoning and judgment. One skill that is yet unexplored for people with IDD is comparing the cost of an item to the amount of money an individual has in order to determine if they can cover the purchase. This skill requires mathematical problem solving and reasoning and, once acquired, can contribute to independence in budgeting and purchasing.

The emerging body of research on MSBI shows it is a promising practice for teaching individuals with IDD to solve word problems, including ones related to personal finance. What is unknown is whether MSBI is an effective strategy for teaching more advanced mathematics skills (i.e., multiplication, multiple-step calculations) to students with IDD, and if these skills generalize when presented with real-world stimuli. Therefore, the purpose of this study was to evaluate the effects of MSBI on multiplicative problem solving related to personal finance for secondary students with IDD.

This study sought to build upon prior research to support a contextualized mathematics approach to mathematics instruction, while addressing concerns and challenges arising from past studies. The findings of Root, Saunders et al. (2017) indicate students with IDD can learn addition and subtraction skills related to personal finance through MSBI. The current study sought to extend this work by using MSBI to teach personal finance skills requiring multiple calculations and operations. In addition, we were interested in whether supplementing MSBI with additional contextualization strategies, such as using videos and real-world stimuli, would result in generalization of mathematics skills. Although a series of studies by Bouck and colleagues found high school students with IDD could compare prices and choose the lowest price item (Bouck et al., 2016; Weng & Bouck, 2014; 2016), research has not yet attempted to teach students to compare the cost of an item to a given amount of money to judge their ability to cover the cost.

Method

Participants

Participants were identified for this study in accordance to the following inclusion criteria: (a) secondary student (i.e., enrolled in middle or high school); (b) identified as having IDD (i.e., autism, intellectual disability); (c) parent consent and student assent; (d) English proficiency; and (e) satisfactory score on researcher-created prescreening measure. The prescreening tool was similar to those used in prior MSBI studies (i.e., Browder et al., 2018; Root & Browder, 2017; Root, Browder, Saunders, & Lo, 2017; Root, Henning, & Boccumini, 2018). The tool assessed participant's ability to (a) receptively and expressively identify prices (e.g., $8.67, $3.00, $18.15); (b) identify and draw shapes; (c) transfer numbers to an iPhone calculator; (d) solve double-digit addition and subtraction problems with and without decimals using an iPhone calculator; (e) solve multiplication problems with and without decimals using an iPhone calculator; (f) identify and describe the purpose of receipts and coupons; and (g) solve percent of change word problems involving using a coupon (e.g., 15% off shoes) or

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leaving a tip (e.g., 10% tip to pizza delivery driver). The purpose of the prescreening tool was threefold: (1) to determine whether participants had sufficient mathematical skills to access the instruction yet would still benefit from instruction (items a-c); (2) to ensure participants had not already mastered the targeted skill (item g); and (3) to assess entry-level mathematics skills to understand instructional needs (items d-f). A participant achieved satisfactory performance on the prescreening measure if he or she completed items (a) through (c) with 100% accuracy and item (g) with no more than 25% accuracy. A member of the research team administered the Test of Mathematical Abilities–Third Edition (TOMA-3; Brown, Cronin, & Bryant, 2012) to all participants to gain a standardized measure of their mathematical abilities.

One female and two male participants diagnosed with autism and intellectual disability participated in this study. Although standardized assessment information related to disability status (i.e., IQ, adaptive behavior) were not available to the research team, teachers confirmed participants were eligible for alternate assessments aligned with alternate achievement standards. All participants received daily instruction in a special education classroom for students with varying exceptionalities. Mathematics instruction was included within the academic structure of the classroom and was delivered by the classroom teacher or paraprofessional to the entire class. One-on-one assistance was available to the participants as needed by the teacher, paraprofessional, or therapist(s).

Sonia (pseudonym) was an 18-year-old Caucasian female with autism and intellectual disability. Throughout the entire study, Sonia demonstrated focus and attention, and was very meticulous in the completion of tasks. She required no additional reading assistance during intervention and was able to verbally communicate with the interventionist as needed. During the prescreening, Sonia was unable to identify the receipt or coupon. She used mental math to solve some of the addition and subtraction problems and had variable accuracy on solving the remaining calculation problems using the calculator. She was unable to solve any of the word problems, though she did attempt them all. Her overall math ability index according to the TOMA-3 was very poor, with subtest scores ranging from the 1st to 9th percentile (see Table 1).

Jason (pseudonym) was a 13-year-old Caucasian male with autism. Throughout the study, Jason was often accompanied by a behavior therapist. At times he was distracted and hesitant to engage in tasks, yet at other times he was excited and approached tasks eagerly. Although he was capable of verbally communicating with the interventionist, he often mumbled or whispered and had to be prompted to provide audible answers or provided with an alternate means of fulfilling required tasks, which included the use of gestures and pointing. Jason also requested scenarios be read to him. During the prescreening, Jason was able to identify the receipt and coupon. He had difficulty using the calculator for all operations, but was able to self-correct. Jason attempted all four word problems but was unable to correctly solve them. His overall math ability index according to the TOMA-3 was very poor, with a relative strength in mathematics in everyday life (25th percentile) but performance

Table 1
Participant Demographics and Standardized Mathematics Scores

Demographics				*Overall Math*	TOMA-3 Subtest Scores Percentile Rank					
Pseudonym	Age	Gender	Ethnicity	*Ability Index*	*MS*	*CO*	*ML*	*WP*	*AT*-pre	*AT*-Post
Sonia	18	Female	White	66 Very Poor	5%	9%	2%	<1%	84% Above average	84% Above average
Jason	13	Male	White	68 Very Poor	16%	<1%	25%	<1%	50% Average	25% Average
Bobby	13	Male	White	52 Very Poor	<1%	<1%	<1%	<1%	9% Below average	37% Average

Note. TOMA-3 = Test of Mathematical Abilities-Third Edition; MS = Mathematical Symbols and Concepts; CO = Computation; ML = Mathematics in Everyday Life; WP = Word Problems; AT = Attitude Toward Math (social validity measure).

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in less than the 1st percentile in computation and word problem solving (see Table 1).

Bobby (pseudonym) was a 13-year-old Caucasian male with autism. Bobby was very conversational during sessions and required no reading assistance. During the prescreening, Bobby was able to identify and describe the purpose of the receipt and coupon and correctly use the calculator for all operations. He diligently worked on all word problems but was unable to come to the correct answer, even stating, “Don’t think it’s right but don’t know another way.” According to the TOMA-3, he had an overall math ability index in the very poor range, with scores across all subtests below the 1st percentile (see Table 1).

Setting and Interventionist

This study took place in a small private school for students with disabilities located in a suburban town in the southeastern United States. All participants were part of the same middle/high school class. They each received academic instruction in core content from a special education teacher and participated in weekly opportunities to enhance vocational training skills. Intervention sessions were conducted one-on-one with each participant in accordance to the intervention schedule. Sessions were conducted in a small room adjacent to the participants’ classroom. A Caucasian female doctoral student in special education was the interventionist for all sessions. The interventionist was a former teacher and administrator at this school, and held a valid teaching certification in elementary education. She had 30 years of experience working with students with and without disabilities (prek–12th grade). She was trained in study procedures by the first and second authors in a 1-hr meeting through behavioral skills training (Reid & Parsons, 1995).

Targeted Skills

The targeted mathematical skills included solving percent of change word problems and comparing quantities. These skills were chosen as they could lead to increased independence in personal finance and supported grade-aligned state standards in mathematics (www.cpalms.org). The targeted mathematics skills (solving percent of change problems and comparing quantities) were aligned to high school algebra standard of solving equations with one or two variables and explaining the process (MAFS.912.A-REI.1.AP.1.A).

Materials

Materials were created for this study by the authors following guidelines from prior research using MSBI (Spooner et al., 2017) and video anchors (Creech-Galloway et al., 2013). Student materials included: (a) a community theme menu displaying 15 community locations with labels and pictures in a 3x5 grid; (b) an iPad mini; (c) researcher-created video anchors for applying the targeted skill in each community location; (d) worksheets displaying one word problem on each side aligned with a community location, the 6-step student task analysis, and graphic organizer (see Figure 1); (f) a calculator on the iPad; and (g) an Excel

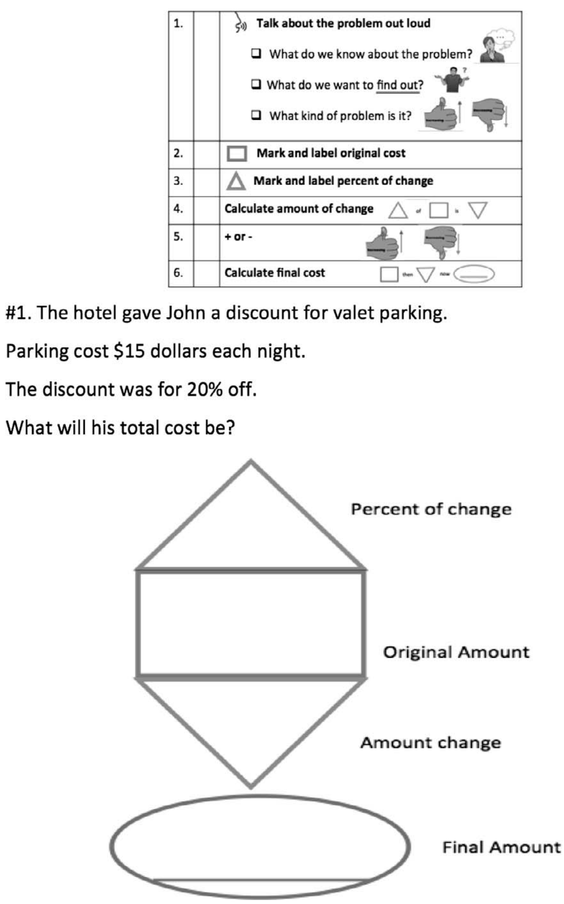

Figure 1. Example student worksheet, including task analysis, word problem, and graphic organizer.

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workbook on the iPad for self-graphing of progress during intervention sessions.

The authors chose 15 community locations where participants would be able to apply the targeted mathematics skill (e.g., carwash, coffee shop, hair salon, delivery food). A 30-40s video anchor was created for each community location to contextualize mathematics instruction. Each video depicted a young adult demonstrating appropriate behavior in each location and the targeted mathematics skill with a narrator providing explanation. For example, "When we want food brought to us, we can have it delivered. Sometimes we order online or by phone. We give the restaurant our address so they can bring it to us. Once the delivery man or woman arrives, they will give us our bill. If we have a coupon, we give it to them to make the cost of our meal less expensive." Two word problems were developed to correspond with each of the 15 community locations, for a total of 30 word problems. Each problem was written using a formulaic approach, structured in a four-line format (Spooner et al., 2017). The first sentence provided the context, the second and third sentences provided the cost of the total bill and the amount of discount on the coupon, and the fourth sentence asked how much the total bill or cost was (see Figure 1).

Design and Measurement

A single-case multiple probe across participants design was used (Ledford & Gast, 2018). Implementation of the design adhered to What Works Clearinghouse guidelines for single-case design (WWC; Kratochwill et al., 2013). This design was chosen as it was hypothesized that the acquisition of mathematical problem-solving skills was not reversible, therefore making a withdrawal type design inappropriate. Further, the multiple probe design reduces testing fatigue by minimizing the number of baseline sessions required of participants while maintaining criteria for visual analysis (Kratochwill et al., 2013). There were four experimental conditions: (a) baseline, (b) intervention, (c) generalization, and (d) maintenance. All participants began baseline simultaneously and were continuously probed for a minimum of five sessions. Once the first participant demonstrated an increase in level and trend for at least three data points, the second participant received three consecutive baseline probes and entered intervention. This systematic introduction to intervention was repeated for the third participant. Mastery criteria during intervention sessions was set at 20 of 24 steps performed independently across both word problems presented for two sessions with an additional requirement of a correct response to Step 7 (e.g., "enough money") for both problems for at least one session. Participants then proceeded to the generalization training phase and continued until they received 20 out of 24 points on both generalization problems, including Step 7 (see Dependent Variable for description of points). Then the maintenance condition began, and at least one maintenance data point was collected for a minimum of 1 week postintervention.

Dependent variables. Two dependent variables were measured throughout the study. The primary dependent variable was mathematical problem solving, defined as the number of points a participant received for independently performing steps of the task analysis. The six steps of the task analysis and the judgement question (Step 7) were worth a total of 12 points, as some steps were measured as two separate behaviors (see Table 2). Two problems were assessed per session for a total of 24 possible points in intervention sessions. The second dependent variable was generalization of problem solving, measured by the number of points a participant earned for independently performing steps of the task analysis.

Reliability and fidelity. To ensure reliability, interobserver agreement (IOA) was taken during a minimum of 30% of baseline, intervention, and generalization sessions across participants. IOA was taken both in vivo and through video observations by the first author and research assistants who were trained in assessment procedures. Baseline IOA was 100% for Sonia across 3/5 sessions (60%), 100% for Jason across 4/7 sessions (57%), and 100% for Bobby across 3/9 sessions (33%). Intervention IOA for Sonia was 98% across 4/7 sessions (57%), 97% for Jason across 8/17 sessions (47%), and 95% for Bobby across 2/6 sessions (33%). Generalization IOA for Sonia was 100% across 2/5 sessions (40%), 100% for Jason across 3/7 sessions (42%), and 93% for Bobby across 4/4 sessions (100%).

Research staff used a checklist to ensure the intervention was implemented as intended. To calculate procedural fidelity, the number of elements correctly implemented was divided by

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Table 2
Steps of Task Analysis and Corresponding Expected Student Response

Step of task analysis	Expected student response
1. Talk about the problem out loud	Reads the provided word-problem scenario or asks to have the problem read aloud and answers 1a-1c
1a. What do we know about the problem?	1a. States or identifies what we know about the problem (original cost and % of discount
1b. What do we want to find out?	1b. Verbalizes or identifies the question
1c. What kind of problem is it?	1c. States or indicates the type of problem (thumbs down—decrease)
2. Mark and label original cost	2. Writes original cost on the graphic organizer in the blue rectangle (including $ symbol and correct decimal placement)
3. Mark and label percent of change	3. Writes the percent of change on the graphic organizer in the point-up red triangle (including % symbol)
4. Calculate amount of change	4a. Multiplies percent of change by original amount using the iPad® calculator
	4b. Writes amount of change on the graphic organizer in the point-down red triangle
5. "+" Or "-"	5a. States or indicates rule for problem type "Discount, decrease, subtract (with thumbs down)"
	5b. Writes symbol for correct operation (-) on the graphic organizer beside amount of change triangle
6. Calculate final cost	6a. Correctly subtracts amount of change from original amount using the iPad® calculator
	6b. Writes correct final cost on the graphic organizer in the purple oval (including & symbol and correct decimal placement)
7. Make judgment regarding purchase	7. Indicates whether given amount of money is "enough" to purchase item or pay for services

the total number of procedural elements and then multiplied by 100. Procedural fidelity was collected during the same sessions as IOA. The mean procedural fidelity during baseline was 100% for Sonia, 100% for Jason, and 100% for Bobby. The mean procedural fidelity during intervention was 98% for Sonia, 98% for Jason, and 100% for Bobby. The mean procedural fidelity during generalization was 100% for Sonia, 100% for Jason, and 93% for Bobby.

Effect size estimate. The field has not reached a consensus on the most appropriate effect size measure for single-case research. Tau-U is a nonparametric effect size that is a promising measure as it is stable and controls for monotonic trends in baseline (Vannest & Ninci, 2015). The third author calculated Tau-U using a free online calculator (singlecaseresearch.org; Vannest, Parker, Gonen, & Adiguzel, 2016). According to Vannest and Ninci, a Tau-U of .20 is interpreted as small, .20-.60 moderate, .60-.80 large, and above .80 very large effect.

Procedures

Throughout the study, participants received mathematics instruction from their special education teacher. Ongoing classroom instruction through the duration of the study included whole and small group formats targeting addition and subtraction with regrouping, multiplication facts (doubles), addition and subtraction with money using the next-dollar strategy, telling time, graphing, and order of operations. No instruction on word problem solving, percent of change, or comparing quantities was provided.

General procedures. Each baseline and intervention session followed the same order of activities. Participants were provided with the community theme menu, a relevant video model, two worksheets with relevant community word problems, a task analysis and graphic organizer (Figure 1), and an iPad calculator. Participants were told they were going to solve two math word problems about spending money in the community. They were instructed to select a community location from the provided menu of 15 community themes. Participants crossed out the theme with a dry erase marker after it was selected to ensure they did not repeat a theme until all had been selected. Once they selected their community location, they were instructed to watch the anchor video on the iPad about how they might use mathematics at that location. Then participants were given the double-sided worksheet containing two problems corresponding with the selected community theme and were told to "solve the problem." After solving each problem, the interventionist asked a follow-up question related to the word problem to test whether the participant was able to determine if the character in the word problem scenario had enough money to cover the cost of the purchase or pay their bill. For example, for car wash, the interventionist asked "What if Jan had $14. Would she have enough money to get her car washed?" A script was used to ask these questions to ensure that the quantities were randomized.

Baseline. Baseline sessions followed the general procedures as described above. Participants were told they could ask for anything to be read aloud if they needed, but no other help could be given. No prompting or feedback were provided during baseline sessions. Participants were allowed to continue working on the problems until they indicated they were finished.

Pre-Unit. Following baseline but prior to intervention, each participant completed a one-day pre-unit with the instructor. This pre-unit was designed to target skills in isolation using explicit instruction in order to reduce cognitive load during intervention. The pre-unit taught: (a) reading and writing dollar amounts, (b) reading and writing percentages, and (c) understanding place value representation of dollar amounts in the calculator (e.g., 4.5 is the same as $4.50).

Intervention. Intervention using MSBI began with 3 days of modeling. On the first day, the instructor used a scripted lesson plan to provide an overview of the targeted mathematics concept and the relevance of this concept to using coupons to make purchases in the community. The scripted lesson plans are available from the first author upon request. Participants were introduced to the graphic organizer and how it would assist them in solving the problems. Finally, the instructor used a T-chart sorting activity to role-play scenarios of having enough or not enough to cover a purchase.

During the second and third days of modeling, the instructor followed a scripted lesson plan to provide MSBI to the participants following the steps on the student's task analysis. During these training days, the interventionist modeled each step and provided instruction on the mathematical process and vocabulary for each step (e.g., "When you see 'percent of' in math it tells you to multiply. What does percent of mean?"). The interventionist taught participants to use an "enough money" rule (e.g., Having enough money means the amount of money you have is the same as (use "=" sign) or more than (use ">" sign) the cost. To model this step and ensure conceptual understanding, the interventionist provided a variety of real-world examples to practice using the "enough money" rule. See Table 2 for a list of the expected (and measured) behaviors for each step of the task analysis.

Following 3 days of modeling, the interventionist used least intrusive prompting if the participant failed to make a response. The prompting hierarchy included: (a) scripted verbal prompts that referred the student back to the checklist, (b) specific verbal prompts that instructed the student with exactly how to perform the step, and (c) scripted model statements to use as error correction for incorrect responses. For independent student responses, scripted positive and specific feedback was provided.

Once the participant finished both problems, the session was concluded with a review and self-graphing of the day's progress along with the setting of a new goal. The purpose of the daily goal setting and self-graphing of progress was to build self-determination skills of the participants and assist them in understanding the progress they were making toward mastery of the targeted skills. The review included the following questions: (a)What type of problems did you solve?; (b)What was your goal today?; (c)You were able to get __ steps independently correct today. Let's graph your progress; and (d) What would you like your goal to be for tomorrow? Participants were aided in setting appropriately ambitious goals for the number of steps to complete independently correct in the next session through a review of prior progress and the ultimate goal of mastery.

Generalization probes. Generalization probes were designed to measure the degree to which students were able to generalize problem-solving skills to realistic stimuli (i.e., receipts, menus, and coupons). Therefore, participants were given a modified worksheet that only contained the graphic organizer and task analysis. Participants followed the general procedures of selecting a community location from the menu and watching the corresponding anchor video. The instructor then presented them with unique realistic stimuli for each of the two generalization problems in each probe (coupons, receipts, and menus as described previously). The interventionist then verbally told participants while gesturing what they were purchasing and asked what their total cost would be if they were using the provided coupon. No additional prompting or error correction was used.

Generalization training. During generalization training the interventionist utilized the same procedures used during generalization probes. However, instead of the participant completing the steps of the process independently, the interventionist modeled the use of the graphic organizer by applying each step of the task-analysis using the real-world menus, receipts, and coupons. Throughout the training, the interventionist gauged the participant's understanding and provided additional guidance and training as needed.

Maintenance. After each participant met mastery criteria of 20 out of 24 steps performed independently across both problems for two sessions, including correct responses to Step 7 (e.g., "enough money") for both problems, he or she moved into maintenance condition. The maintenance condition employed the same procedures and protocol as used during intervention sessions. Maintenance data were collected once weekly for each participant.

Social Validity

Participants were asked to fill out the Attitude Toward Math subtest of the TOMA-3 pre-and post-intervention to measure the degree to which the intervention had an effect on participant's attitudes about mathematics instruction or self-perception regarding their abilities and achievement. This subtest contains 15 questions on a Likert-type scale (Yes, definitely!; Closer to yes; Closer to No; No, definitely!) In addition, participants engaged in a postintervention interview with open-ended questions regarding: (a) what they feel they learned in the study, (b) how they might apply what they learned, (c) their favorite part of the study, (d) what made solving problems easier, (e) what made solving problems harder, and (f) if they would recommend a friend participate in the same study.

Results

Figure 2 displays the results of three students' use of MSBI to solve word problems based on community purchasing scenarios reflected as the number of correct independent steps on the task analysis for two problems (12 points per problem; two problems assessed per session for a total of 24 possible points). All three participants demonstrated an immediacy of effect and a change in level following the implementation of MSBI, indicating a functional relation. Data continued to show an accelerating trend with no overlapping data with baseline across all participants. Statistical analysis confirmed a presence of a large effect, with a Tau-U of .87.

During baseline, Sonia demonstrated an average of 4.2 independently completed correct steps of the task analysis (range 1-6, median = 4) across five sessions (10 total problems). In intervention, Sonia showed an increase of correct independent steps with an average of 20.1 (range 13-24; median = 22). She reached mastery in seven sessions. Sonia showed an increase in generalization to real-world stimuli from baseline scoring 2 points to 6 and 10 points, respectively, in intervention. After meeting mastery criteria, Sonia received generalization training for two sessions, and her subsequent scores demonstrated 100% accuracy across both problems for each generalization session.

During baseline, Jason demonstrated an average of 1.1 independently completed correct steps of the task analysis (range 0-2, median = 1) across

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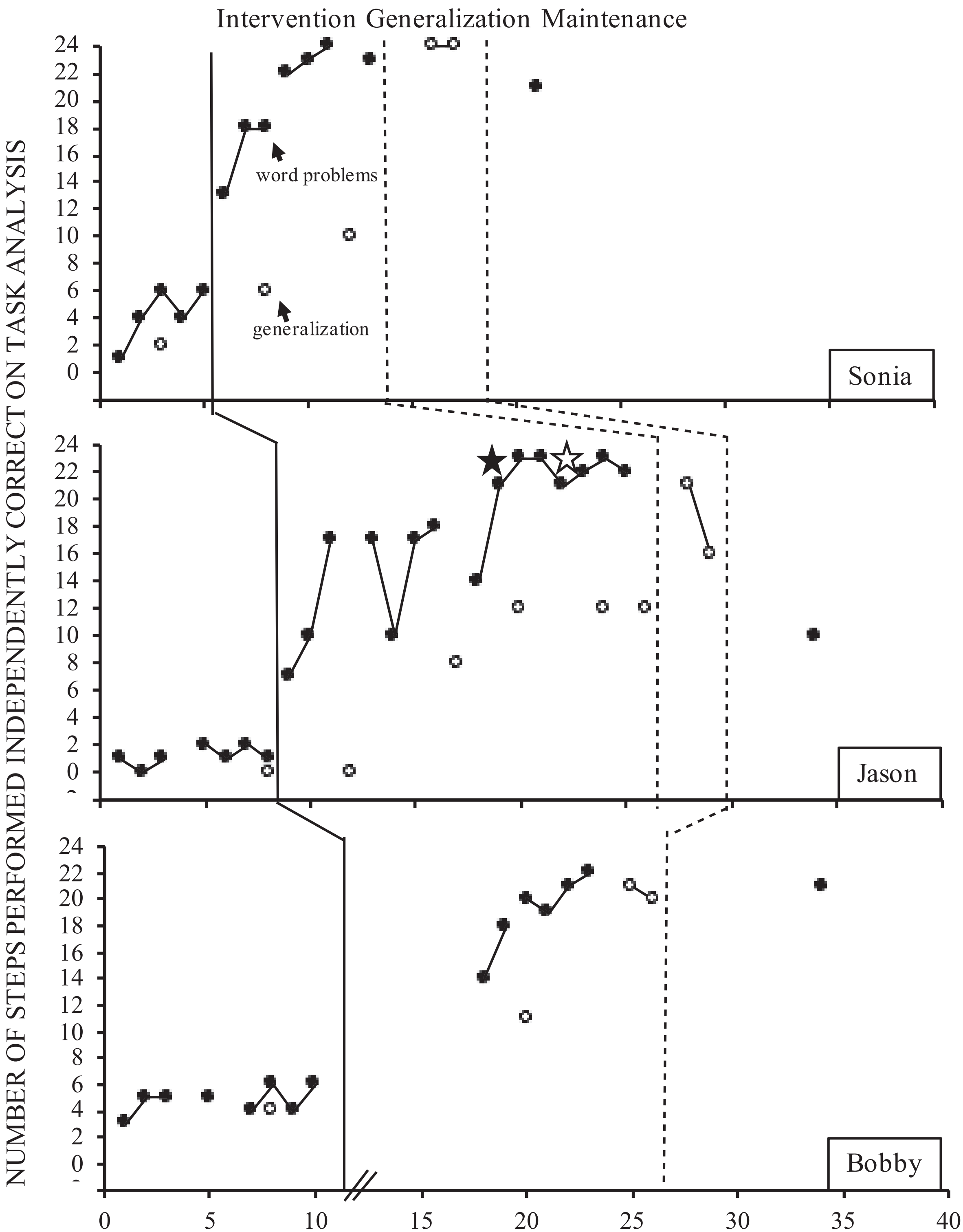

Figure 2. Graph of number of steps of task analysis completed independently correct. Closed circles indicate word problems, open circles indicate generalization problems. The hash marks for Bobby indicate a prolonged absence from school.

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seven baseline sessions. In intervention, Jason showed an increase of correct independent steps with an average of 18.2 (range 7-24; median = 20). Jason showed some variability in his data during intervention. Upon analyzing the data, it was determined that Jason skipped steps that required verbal responding (i.e., 1a, 1b, 1c); therefore, prior to the ninth intervention session, the interventionist showed him alternative methods for indicating his responses, such as using gestures or pointing (indicated by the closed star in Figure 2). This improved stability of his data, but he was still unable to reach mastery as he was demonstrating variability in responding to Step 7. Researchers determined he would benefit from additional explicit instruction on the "enough money rule" prior to the session starting, beginning on his 12th intervention session (indicated by the open star in Figure 2). Jason was able to reach mastery in 15 sessions. Jason showed an increase in his generalization of problem solving from a baseline of 0 to a mean of 8.8 (range 0-12; median = 12) points in intervention. Following two sessions of generalization training, he showed an increase in generalization to an average of 16.3 points (range 12-21, median = 16) across three follow-up sessions.

In baseline, Bobby demonstrated an average of 4.8 independently completed correct steps of the task analysis (range 3-6; median = 5) across eight baseline sessions. In intervention, Bobby showed an increase of correct independent steps, with an average of 19 (range 14-22, median = 19.5). Bobby reached mastery in six sessions. Bobby demonstrated an increase in generalization during probes from 4 points in baseline to 11 after three intervention sessions. After meeting mastery, he scored 21 and 20 points and, thus, did not require generalization training.

Social Validity

Findings from the TOMA-3 Attitude Toward Math subtest was administered pre-/post-intervention as a social validity measure. Overall scores can be seen in Table 1. Sonia and Bobby's answers from pre- to post-test did not reflect meaningful changes in their attitude toward math as a result of participating in the study. Jason's responses, on the other hand, indicated an extreme positive shift for 5 of 15 items, moving his attitude from the 9th percentile (below average) to the 37th percentile (average). Two examples that reflected these shifts from "*No, definitely*" to "*Yes, definitely*" ratings included: (a) Item 1: "It's fun to work math problems" and (b) Item 5: "Math is interesting and exciting." During the social validity interview, all three participants stated they had learned something from the study and were able to provide an example of how they might apply those skills in a community setting. Each participant identified their favorite part (e.g., finding out the total cost, learning new things) and was also able to identify components of the study that made solving the problems easier or harder. Finally, two of the three participants (Bobby and Sonia) stated they would recommend that a friend participate in the same study.

Discussion

The purpose of this study was to evaluate the effects of MSBI on multiplicative problem solving for secondary students with IDD, building on prior research targeting personal finance skills related to problem solving and price comparison. Visual analysis of results indicates a functional relation between MSBI and problem solving, which was confirmed by a large effect size (Tau-U of .87). Further, participants were able to compare the final discounted price of an item or activity to a given amount of money to determine if they would have enough to make the purchase, as well as generalize acquired mathematical skills from word problems to real-world stimuli (i.e., receipts, menus, coupons).

Personal finance skills have long been recognized as influencing the independence of individuals with extensive support needs (Browder & Grasso, 1999). We wish to expand the consideration of what specific skills should be targeted to build competence in this area (Root, Knight, & Mims, 2017; Root, Saunders, et al., 2017; Saunders et al., 2018). The current study provides an example of contextualizing grade-aligned academic instruction in a way that promotes personal relevance (Trela & Jimenez, 2013). Participants were taught a complex mathematical task (i.e., solving percent of change word problems) that was anchored within a meaningful context (i.e., finding a discounted price). In addition, they were able to go beyond price comparison tasks accomplished in prior studies, directly addressing gaps identified by researchers to address reasoning and judgment skills (e.g., Bouck et al., 2016; Weng & Bouck, 2014; 2016). This study was the first to combine mathematical word problem solving, a skill touted by mathematics education experts as critical for developing real-world problem-solving skills (National Council of Teachers of Mathematics, 2000), with price comparison. The goal of the intervention was for participants to not only calculate the discounted price, but also to determine if they had enough money to make the purchase. Findings support the use of MSBI to teach word problem solving to students with extensive support needs (Spooner et al., 2017) and are among the first to demonstrate that students with IDD can learn complex multiple step problems (i.e., multiplication, percent of change).

The focus on building skills that will increase independence and opportunities for individuals to live, work, and have fun in inclusive communities (Brown et al., 1979) has influenced our perception of social validity of academic interventions for students with IDD. Academic skills that can be applied within multiple daily living, vocational, and leisure contexts will increase quality of life (Spooner & Browder, 2015; Taber-Doughty, 2015). During the social validity interview, all three participants were able to articulate when they would use these skills in the community. Further, Bobby was able to say why this was an important skill to have, stating

> If I was to go to like Walmart and have a coupon for Walmart or have a coupon for Burger King, calculating how much the final amount is going to be after I give the coupon to ensure that I have enough money. Cause there usually is an ATM right around the corner.

When considering social validity of interventions, it is also important to consider perceptions of feasibility and efficacy. As displayed in Figure 2, Jason experienced more difficulty with some steps of the task analysis than Sonia or Bobby, specifically those that initially required a vocal response (Step 1) and relied on auditory input (Step 7). He reflected this feeling in his social validity interview, as he said "trying to say it" was what made solving problems more difficult. In response to these difficulties, the interventionist provided Jason with alternate response modes (i.e., pointing, using gestures) and provided written information along with auditory information. Providing multiple means of representation and expression are core components of universal design for learning (UDL; Gordon, Meyer, & Rose, 2016), a framework with which this intervention was explicitly aligned. Yet, findings and participant feedback demonstrate that, even with intentional pre-planning to meet the needs of learners with extensive support needs, data-informed decision making and gathering input from individuals themselves is critical.

Implications for Practice

Teachers may feel the tension between curricular emphases in a different way than years past (i.e., Agran et al., 2003). High-stakes accountability assessments measure performance through test scores on alternate assessments, yet students with IDD continue to need instruction on daily living tasks, personal, and social/communication skills (Collins et al., 2011; Root, Knight, et al., 2017). This tension may increase as students reach secondary grades and prepare for transition to adulthood. Contextualized instruction is one way to meet multiple priorities of students within academic instruction. Practitioners can use MSBI to teach students to conceptually understand mathematical content and then apply it in meaningful contexts. Self-determination skills such as goal setting, self-monitoring, and self-graphing can be naturally incorporated into problem solving as students set a goal for how many steps or problems they want to get independently correct, monitor progress toward the goal, and either self-graph on paper or using an electronic form such as Google sheets or Excel. Involving students in monitoring daily progress provides natural occasions to discuss their perceptions of interventions and incorporate meaningful opportunities for self-advocacy. Some individuals may need adjustments like Jason, or have insightful suggestions to improve instruction such as Bobby.

Limitations and Suggestions for Future Research

The design and procedures of this study bring up several limitations that are important to consider as we look toward future research in this area. First, the measurement of Step 7 wherein participants stated whether they had enough money to cover the purchase was presented as a dichotomous yes/no response, giving participants a 50% chance of a correct answer. Requiring an answer that included an explanation of why they did or did not have enough money, such as stating that the discounted price was more than or less than their given amount of money, would have been a more comprehensive measurement of conceptual understanding.

Second, although participants were able to generalize problem solving from word problems to natural stimuli (i.e., coupons, receipts, menus), they were still provided with the graphic organizer and task analysis. Relatedly, the current study was not able to measure generalization in a real-life setting (e.g., in the actual community locations). Future research should further fade the visual supports and test generalization within natural contexts (i.e., community settings). Bobby brought up this very point during one intervention session when he stated he would not be able to bring this graphic organizer to help him in a store, a statement that seemed to refer to negative social stigma that would be associated with it. It is likely individuals with extensive support needs will continue to need supports of some sort, at least during in the initial phases of learning. Future research could explore the use of technology-based task analyses or graphic organizers on electronic devices such as smartphones or tablets as a more socially acceptable support (Mechling, 2011; Saunders et al., 2018), something Bobby stated he would like to test out himself.

This intervention used a treatment package, one component of which was MSBI. Additional strategies included video anchors and goal setting. Given that a component analysis was not conducted, it is not possible to determine which components of the intervention were responsible for changes in mathematical problem solving. It is also not possible to determine whether all components were necessary to achieve the desired outcome. Future research should address this by evaluating the relative effects of each component. Such studies could provide valuable information to practitioners and researchers alike on tailoring research-based practices to the needs of students with IDD.

Finally, future research should focus on the feasibility of implementation of MSBI. The current study was implemented by a doctoral student who had over 30 years of experience teaching students with disabilities in a one-on-one setting. Although these results indicate the intervention was effective, it is unknown whether it would be feasible for a special education teacher to implement the intervention or if results would be similar in a small group setting. Prior MSBI research has found middle school peers without disabilities can implement MSBI with fidelity (Davis, 2016). Future systematic replications of the current study should strategically address these limitations.

Conclusion

In this study, secondary students with IDD learned to solve personal finance word problems requiring multiple operations (i.e., multiplication, subtraction). In addition, students learned to generalize their word problem solving skills to real-world problems involving natural stimuli (i.e., coupons, receipts, and menus). Prior studies that addressed word problem solving skills of students with IDD focused on single-step additive problems and included younger students. Although this study shows promise that secondary students with IDD can acquire and generalize more complex mathematical skills, more research is needed to replicate the findings, with an emphasis on feasibility of implementation by teachers in additional instructional formats (i.e., small groups, in inclusive classrooms).

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des rôles du personnel qui offre du soutien aux élèves, les types de soutien dont le personnel et les élèves ont besoin pour réussir, les avantages dont bénéficient les élèves et les obstacles à leur inclusion.

Contextualisation des mathématiques : l'enseignement de la résolution de problèmes à des élèves du secondaire ayant une déficience intellectuelle

Jenny R. Root, Sarah K. Cox, Nannette Hammons, Alicia F. Saunders et Deidre Gilley

L'objectif de cette étude était d'évaluer l'effet d'une intervention à plusieurs composantes en mathématique (instruction basée sur des schémas modifiés, vidéos d'ancrage et établissement de buts à partir de graphiques auto-rapportés) sur les habiletés de résolution de problèmes en mathématique chez des élèves du secondaire ayant une déficience intellectuelle. Trois participants ont reçu un enseignement visant la résolution d'un problème écrit de conversion de pourcentage. Dans ce problème, les participants devaient calculer le prix d'un produit ou d'une activité à la suite de l'application d'un rabais obtenu par le biais d'un coupon et déterminer s'ils avaient assez d'argent pour en faire l'achat. Les résultats des multiples réponses des participants indiquent une relation fonctionnelle entre les interventions et la résolution de problèmes. Tous les participants ont été en mesure de généraliser les habiletés de résolution de problèmes à des situations issues de la réalité quotidienne (c.-à-d., des coupons, des reçus, des menus). Les implications pour la recherche et les pratiques futures sont discutées.

Prédicteurs des inscriptions à des cours inclusifs en enseignement supérieur par des étudiants présentant une déficience intellectuelle

Clare Papay, Meg Grigal, Debra Hart, Ngai Kwan et Frank A. Smith

Les programmes d'enseignement supérieur pour les étudiants ayant une déficience intellectuelle (DI) offrent des occasions de participation à des expériences universitaires, y compris l'accès à des cours. La présente étude visait à examiner les données de programmes financés par le gouvernement fédéral afin de décrire et de déterminer les facteurs prédictifs de la participation à des cours inclusifs. Les données de 672 étudiants de première année ayant une DI inscrits à 3 233 cours universitaires inclusifs ont été analysées. Les prédicteurs significatifs étaient l'âge de l'étudiant, si l'étudiant suivait un programme offrant l'accès à un conseiller ou s'il recevait des notes retranscrites, si l'étudiant suivait des cours spécialisés, et si l'étudiant avait un travail rémunéré ou avait participé à des expériences particulières de développement de carrière. Les implications pour les programmes d'enseignement supérieur sont discutées.

L'éducation inclusive : perspectives sur la mise en œuvre et les pratiques selon des experts internationaux

Jennifer A. Kurth, Amanda L. Miller, Samantha Gross Toews, James R. Thompson, Mónica Cortés, Mukunda Hari Dahal, Inés E. de Escallón, Paula Frederica Hunt, Gordon Porter, Diane Richler, Indiana Fonseca, Ruchi Singh, Jan Šiška, Rolando Jr. Villamero et Fatma Wangare

Chaque enfant a le droit à l'éducation, y compris les enfants présentant des incapacités. Les résultats des recherches à travers le monde ont montré les avantages de l'éducation inclusive, et des règlements permettant de fournir une éducation accessible et inclusive peuvent également être trouvés dans les politiques nationales et les accords internationaux. Cet article explore les perspectives de 11 experts internationaux sur l'état de l'éducation inclusive dans des pays des cinq continents. Des experts ont participé à une discussion de groupe au 17e congrès mondial annuel d'inclusion internationale de 2018, à Birmingham, au Royaume-Uni. Les participants ont échangé sur les multiples facteurs influençant les pratiques éducatives inclusives. En se basant sur leurs expériences, les participants ont également discuté de stratégies jugées efficaces ou inefficaces en fonction de divers éléments contextuels. Les implications pour les politiques, la recherche et la pratique sont discutées.

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y los estudiantes requieren para tener éxito, los beneficios experimentados por los estudiantes y las barreras para incluirlos.

Contextualizando Matemáticas: Enseñando la Resolución de Problemas a Estudiantes de Secundaria con Discapacidades Intelectuales y del Desarrollo

Jenny R. Root, Sarah K. Cox, Nannette Hammons, Alicia F. Saunders y Deidre Gilley

El propósito de este estudio fue evaluar el efecto de una intervención matemática de múltiples componentes (instrucción basada en un esquema modificado, anclas de video y establecimiento de metas con auto-graficación) en las habilidades de resolución de problemas matemáticos de estudiantes de secundaria con discapacidades intelectuales y de desarrollo. Se enseñó a tres participantes a resolver el porcentaje de problemas de palabras de cambio, lo que implicaba calcular el precio descontado de un artículo o actividad después de usar un cupón y luego determinar si tenían suficiente dinero para realizar la compra. Los resultados de la prueba múltiple en el diseño de los participantes indican una relación funcional entre la intervención y la resolución de problemas, y todos los participantes pudieron generalizar las habilidades de los problemas de palabras a los estímulos del mundo real (es decir, cupones, recibos, menús). Se discuten las implicaciones para la práctica y la investigación futura.

Predictores de Inscripciones en Cursos Inclusivos en Educación Superior por Estudiantes con Discapacidades Intelectuales y del Desarrollo

Clare Papay, Meg Grigal, Debra Hart, Ngai Kwan y Frank A. Smith

Los programas de educación superior para estudiantes con discapacidades intelectuales y de desarrollo (DID) ofrecen oportunidades para participar en experiencias universitarias, incluido el acceso a cursos universitarios típicos. El propósito del presente estudio fue examinar los datos de los programas financiados con fondos federales para describir e identificar predictores de inscripciones de cursos inclusivos. Se analizaron los datos de 672 estudiantes de primer año con DID que se inscribieron en 3,233 cursos universitarios inclusivos. Los pronosticadores significativos fueron la edad del estudiante, ya sea que el estudiante asistiera a un programa que ofreciera acceso al asesoramiento regular del estudiante o proporcionara una transcripción oficial, si el estudiante tomó algún curso especializado y si el estudiante tenía un trabajo remunerado o participó en un desarrollo profesional. Se discuten las implicaciones para los programas de educación superior.

Educación Inclusiva: Perspectivas de Implementación y Práctica de Expertos Internacionales

Jennifer A. Kurth, Amanda L. Miller, Samantha Gross Toews, James R. Thompson, Mónica Cortés, Mukunda Hari Dahal, Inés E. de Escallón, Paula Frederica Hunt, Gordon Porter, Diane Richler, Indiana Fonseca, Ruchi Singh, Jan Šiška, Rolando Jr. Villamero y Fatma Wangare

Todos los niños tienen derecho a una educación, incluidos los niños con discapacidad. Los resultados de investigaciones de todo el mundo han demostrado los beneficios de la educación inclusiva, y los mandatos para brindar una educación accesible e inclusiva también se pueden encontrar en las políticas nacionales y en los acuerdos internacionales. Este artículo explora las perspectivas de 11 expertos internacionales sobre el estado de la educación inclusiva en países de 5 continentes. Los expertos participaron en una discusión de grupos focales en el 17° Congreso Mundial Anual 2018 de Inclusion International en Birmingham, Reino Unido. Los participantes compartieron factores multifacéticos que impactan las prácticas educativas inclusivas. Sobre la base de sus experiencias, los participantes también discutieron estrategias que se consideraron efectivas o ineficaces según diversos elementos contextuales. Se discuten las implicaciones para la política, la investigación y la práctica.

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