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An Updated Evidence-Based Practice Review on Teaching Mathematics to Students With Moderate and Severe Developmental Disabilities

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Abstract

The purpose of this review was to examine the body of research on teaching mathematics to students with moderate and severe developmental disability that has been published since 2005, reflecting changes in both the academic expectations for this population and research and design standards in the evidence-based practice (EBP) era. We examined research on teaching mathematical skills for students with moderate and severe developmental disability from 2005–2016 and found 36 studies (33 single-case and three group-experimental studies), updating the Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman analysis. Of the 36 studies included in the review, 22 single-case and three group-design studies received a rating of high or adequate quality using the National Technical Assistance Center on Transition (NTACT) indicator criteria. In addition to systematic instruction, instructional procedures of technology-aided instruction, graphic organizers, manipulatives, and explicit instruction were found to be EBPs in teaching mathematics to this population.

Keywords

mathematics, instruction, low-incidence disabilities, exceptionalities, evidence-based practice, autism, curriculum

The importance of high-quality instruction for students with moderate and severe developmental disability, including intellectual disability (ID) and autism spectrum disorder (ASD), continues to be at the forefront of the minds of legislators, researchers, practitioners, and parents. Since the passage of the No Child Left Behind Act of 2001 (NCLB; 2006) and other pieces of relevant legislation such as the Every Student Succeeds Act of 2015 (ESSA; 2015) and Individuals With Disabilities Education Improvement Act reauthorization of 2004 (IDEA; 2004), the emphasis for ALL students, including those with moderate and severe developmental disabilities, has been on teaching grade-aligned academic standards via evidence-based practices (EBPs).

The EBP movement in special education was aided by initial work on identifying quality indicators (QIs) and procedures to assess practices across different research methodologies (e.g., "Criteria," 2005). Following the dissemination of these initial guidelines, researchers in the field of severe disabilities applied proposed standards in comprehensive EBP reviews on teaching academic skills to students with moderate and severe disability (literacy/language arts, Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine 2006; mathematics, Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; science, Spooner, Knight, Browder, Jimenez, & DiBiase, 2011). More recently, methods for systematic EBP reviews have received additional analysis to strengthen their potential contribution to practice (e.g., Cook & Cook, 2013; Kratochwill et al., 2013; National Technical Assistance Center on Transition [NTACT], 2015).

Mathematics remains a particular area of concern. In a national sample of students from five states who took alternate assessments based on alternate achievement standards (AA-AAS), only 4% of students were able to apply computational procedures to solve real-world problems aligned to grade-level standards (Kearns, Towles-Reeves, Kleinert, Kleinert, & Kleine-Kracht Thomas, 2011). Of further concern, another national sample of teachers of students with moderate and severe developmental disabilities felt unprepared to teach mathematics to this population, even when

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given resources such as sample lesson plans built with EBPs for teaching mathematics and content knowledge training in specific domains on mathematics (Lee, Browder, Flowers, & Wakeman, 2016). There is a need to further investigate EBPs for teaching grade-aligned mathematics content.

To date, there have been four comprehensive reviews that have focused on mathematical learning for students with developmental disabilities. Hart Barnett and Cleary (2015) found 11 experimental studies that taught mathematics to students with ASD; however, across the 34 participants, only eight were reported to have ASD and ID. The authors did not evaluate the quality of included studies, thus limiting the implications of their findings for drawing conclusions about the effectiveness of reported practices. Conversely, King, Lemons, and Davidson (2016) used What Works Clearinghouse standards to identify 14 high-quality studies that experimentally evaluated the efficacy of mathematics interventions for 28 participants, only 60% of whom (n = 17) were described as having ID. Authors reported the primary focus of included studies was on functional and computational skills. A third review targeted students with Down syndrome (Lemons, Powell, King, & Davidson, 2015), but none of the nine identified studies met criteria for methodological rigor.

Only one comprehensive review, conducted by Browder et al. (2008), has focused on students with moderate and severe ID as a whole, which included students with ASD and Down syndrome who demonstrated extensive support needs through either IQ or participant description. A total of 68 studies (65 articles with some of them having double experiments), published between 1975 and 2005, were included in the review. The authors evaluated the quality of the 68 experiments using the Gersten et al. (2005) criteria for group designs (n = 14) and the Horner et al. (2005) criteria for single-case designs (n = 54). None of the group-design studies and only 19 of the single-case studies met criteria for methodological rigor. The majority of these studies addressed the National Council of Teachers of Mathematics (NCTM; 2000) components of Measurement (e.g., money, purchasing, and time) and Number and Operations (e.g., calculation skills, number identification, and counting), perhaps reflecting these as primary foci of instruction for this population during the time period under review. On the whole, in vivo instruction (teaching real applications in authentic settings), systematic instruction (e.g., system of least prompts, time delay, specific praise, and error correction), and providing students multiple opportunities to respond were found to be EBP (Browder et al., 2008).

The studies included in Browder et al.'s (2008) comprehensive review reflected research conducted prior to the changes in federal law that required schools to be accountable for all students' performance in mathematics. Since NCLB, states have used alternate assessments for students with significant cognitive disabilities to show mathematical achievement. These alternate assessments have been aligned with states' mathematical standards. This also has been an era in which most states first adopted the Common Core State Standards in Mathematics (CCSSM, www.corestandards.org) or created their own standards using CCSSM or the NCTM as reference points (Lee et al., 2016). Through all of these changes, states have consistently required alternate assessments to examine learning for students with moderate and severe developmental disability in all domains of mathematics (Quenemoen & Thurlow, 2015)

As today's expectations for mathematical achievement are much higher for students with moderate and severe developmental disability than they were a decade ago prior to the passage of NCLB and the reauthorization of IDEA in 2004 (Lee et al., 2016), states now use simplified, prioritized versions of their state's grade-level content standards for the alternate assessment (Quenemoen & Thurlow, 2015). Yet, their impact on the academic learning of students with moderate and severe developmental disability is unknown. There is a need to identify the extent to which the research literature has offered educators guidance to meet current expectations.

The purpose of this review is to examine the body of research on teaching mathematics to students with moderate and severe developmental disability that has been published since 2005, reflecting changes in both the academic expectations for this population and research and design standards in the EBP era. To facilitate comparison between these two bodies of research, the methodology and research questions of this review parallel that of Browder et al.'s (2008) review in two primary ways: (a) through similar inclusion criteria and coding of studies by NCTM standard, with updates to reflect advancement in understanding of how to identify EBPs (NTACT, 2015) and (b) effect sizes to quantify single-case data using a common metric. This article targets four key research questions:

> **Research Question 1:** What NCTM components of mathematics are represented in published literature from 2005–2016?
>
> **Research Question 2:** What types of mathematical skills are being taught to individuals with moderate and severe disability?
>
> **Research Question 3:** How does the content and context of instruction differ between this evidence and articles published before 2005?
>
> **Research Question 4:** What evidence-based instructional practices have been successful in the acquisition of mathematics skills of individuals with moderate and severe disability?

Method

Inclusion Criteria

The criteria for inclusion were the same as Browder et al. (2008) except for the dates of inclusion, which were 1975–2005 for the prior review. Included studies were (a) published in a peer-reviewed journal in English between the years of 2005 and December 2016, (b) included at least one participant identified as having a moderate or severe developmental disability (i.e., autism, developmental disability, or moderate, severe, or profound ID, or participating in alternate assessment if disability not specified), (c) used an intervention that focused on teaching academic mathematics skills and reported firsthand data (reviews of literature were not included), and (d) used an experimental or quasi-experimental design for either group or single-case studies. The criteria for participants with ASD were further specified to target those with moderate or severe ID: those taking alternate assessments aligned with AA-AAS or participant description included extensive level of support need.

Literature Search Procedures

A list of search terms was developed to identify the research base of studies on teaching mathematics to students with moderate and severe disability. The list contained terms related to disability (e.g., autism and ID, moderate and severe ID, severe disabilities), topic of instruction (e.g., mathematics, instruction, numeracy, problem solving), and instructional materials (e.g., manipulatives, graphic organizer, calculator). Authors will share the search terms upon request. Electronic databases used for the search included Academic Search Complete, ERIC, MasterFILE Complete, PsycINFO, SAGE Journals, and WorldCat.org. A manual search was conducted through all issues from 2005 to 2016 in nine special education journals (authors will provide a full list upon request). Finally, an archival search of the references of included studies was conducted to find any studies that may have been missed in the electronic or hand searches.

The initial electronic search produced 1,992 results. Initial screening involved evaluating titles and abstracts to eliminate studies that obviously did not meet inclusion criteria (e.g., nonexperimental studies; did not measure mathematical skill, such as the completion of a chained motor task like using an Automatic Teller Machine (ATM), or only learning mathematics vocabulary; did not include population of interest; or the data for participants with moderate or severe developmental disability were aggregated with data for other disabilities and could not be isolated). Results of this first screening resulted in 63 unduplicated studies. In a second round of screening, the second author read the full text of 63 studies and found 36 that met all inclusion criteria.

Coding for Instructional Variables

All studies that met inclusion criteria were coded for instructional variables. A coding worksheet was developed to highlight the variables from Browder et al.'s (2008) literature review, and included the following areas of focus: (a) NCTM mathematics standard (e.g., Algebra, Number and Operations, Data Analysis, Geometry, Measurement), (b) specific response (e.g., chained or discrete), (c) instructional materials (e.g., technology, graphic organizer, manipulatives), (d) instructional methods (e.g., use of a task analysis, massed trials, explicit instruction, video modeling), and (e) systematic prompting and feedback (i.e., time delay, most to least prompt, system of least prompts, simultaneous prompting, stimulus prompting/fading, chaining procedure). Authors will share the coding checklist, including definitions, upon request.

Coding QIs to Determine EBPs

A two-step process for determining EBPs was used that was similar to that used by Browder et al. (2008). First, authors identified quality studies that used an experimental design to measure the effect of interventions on mathematics (outcome) for individuals with moderate and severe developmental disability. The studies that met inclusion criteria were coded for QIs using recommendations outlined by Horner et al. (2005) for single-case research and Gersten et al. (2005) for group-experimental research, mirroring the method used by Browder et al. The coders used a checklist developed by Test et al. (2009) and updated by NTACT (2015), because they contained detailed operational definitions for coding and directions for determining high or adequate quality based on criteria met using the Horner et al. and Gersten et al. guidelines. The checklists can be found at the NTACT website (http://transitionta.org/effectivepractices). The second author coded all single-case studies for the 21 QIs across eight variables: (a) participants, (b) setting, (c) dependent variable/measures, (d) independent variable/measures, (e) baseline procedures, (f) results, (g) external validity, and (h) social validity as shown in Table 1. It should be noted that coders used visual analysis to evaluate items (e) to (g) on the checklist. A group-experimental QI checklist also was adapted from Test et al. (2009). The second author coded the group-experimental studies for the 10 essential QIs across and 10 desirable QIs across four variables: (a) participants, (b) dependent variable/measures, (c) independent variable/intervention, and (d) results as shown in Table 2 (see Tables 1 and 2).

Each study was given a rating based on the number of QIs that were met using guidelines from NTACT (2015). A single-case study was deemed high quality if it met all QIs and acceptable quality if it met all QIs except participant selection criteria and at least one social validity QI. A group-experimental study was deemed high quality if it met

Table 1. Single-Case QIs.

QIs	Ayres, Langone, Boon, and Norman (2006)	Baker, Rivera, Morgan, and Reese (2015)	Birkan (2005)	Bouck, Satsangi, Doughty, and Courtney (2014)	Browder, Jimenez, and Trela (2012)	Celik and Vuran (2014)	Cihak and Foust (2008)	Cihak and Grim (2008)	Collins, Hager, and Galloway (2011)	Creech-Galloway, Collins, Knight, and Bausch (2013)	Falkenstine, Collins, Schuster, and Kleinert (2009)	Fletcher, Boone, and Cihak (2010)	Hansen and Morgan (2008)	Heinrich, Collins, Knight, and Spriggs (2016)	Horn, Schuster, and Collins (2006)	Hsu, Tang, and Hwang (2014)	Hudson, Zambone, and Brickhouse (2016)	Jimenez, Browder, and Courtade (2008)	Jimenez and Kemmery (2013)	Jimenez and Staples (2015)	Jolivette, Lingo, Houchins, Barton-Arwood, and Shippen (2006)	Karl, Collins, Hager, and Ault (2013)	Leaf, Sheldon, and Sherman (2010)	Rao and Kane (2009)	Rao and Mallow (2009)	Rapp et al. (2012)	Root, Browder, Saunders, and Lo (2016)	Skibo, Mims, and Spooner (2011)	Sy and Vollmer (2012)	Thompson, Wood, Test, and Cease-Cook (2012)	Weng and Bouck (2014)	Weng and Bouck (2016)	Zisimopoulos (2010)
Participants																																	
1. Described sufficiently	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. Selection described sufficiently	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Setting																																	
3. Setting described sufficiently	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dependent variable/measures																																	
4. Described with replicable precision	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5. Quantifiable	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Measurement occurred repeatedly	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Measurement described to replicable precision	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8. Interobserver agreement data reported	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Independent variable/intervention																																	
9. Described with replicable precision	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10. Systematically manipulated	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11. Procedural fidelity described	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X			X		X	
Baseline procedures																																	
12. Evidence of pattern prior to intervention	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. Described with replicable precision	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Results																																	
14. Three demonstrations of experimental effect at different points in time			X	X	X	X	X	X			X		X	X		X		X	X	X		X	X			X	X	X	X	X		X	
15. Design controlled threats to internal validity	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	
16. Demonstrates experimental control		X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X		X	X			X	X	X	X	X		X	
External validity																																	
17. Experimental effect replicated across participants, settings, or materials		X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X		X	X			X	X	X	X	X		X	
Social validity																																	
18. Dependent variable is socially important	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
19. Magnitude of change is socially important		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X			X	X	X	X	X			
20. Independent variable is cost-effective/practical	X	X		X	X				X		X		X	X		X	X					X	X				X			X		X	X
21. Independent variable is implemented over time, typical contexts/typical agents	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		X		X	X
Indicators met/total indicators	17	18	19	21	21	20	20	20	17	20	21	20	21	21	16	20	20	20	20	20	16	21	21	15	15	18	20	20	19	21	15	20	16
NTACT EBP Quality			A	H	H	A	A	A		A	H	A	H	H		A		A	A	A		H	H				A	A	A	H		A	

Note. H = high quality, met all 21 quality indicators. A = acceptable quality, met all QIs except 2 and meets one of 17–20. QI = quality indicator. NTACT EBP = National Technical Assistance Center on Transition evidence-based practice.

Table 2. Group and Quasi-Experimental QIs.

QIs	Browder, Trela, et al. (2012)	Hall, Hustyi, Hammond, Hirt, and Reiss (2014)	Tzanakaki, Hastings, Grindle, Hughes, and Hoare (2014)
Essential QIs			
Participants			
1. Described sufficiently to confirm disability/difficulty	X	X	
2. Procedures increased probability that participants were comparable across conditions	X	X	X
3. Sufficient description of intervention providers	X	X	
Independent variable/intervention			
4. Intervention clearly described and specified	X	X	X
5. Fidelity was described (optional)	X		
6. Comparison conditions are clearly described	X	X	X
Dependent variable/measures			
7. Used multiple measures to balance measures closely aligned with the intervention and measures of generalized performance. (optional)		X	
8. Outcomes are measured at the appropriate times.	X	X	X
Results			
9. Appropriate data analysis techniques linked to key research questions and hypotheses	X	X	X
10. Effect size calculations were reported or data are provided to enable an effect size calculation for the primary dependent variable	X	X	X
Essential indicators met/Total essential indicators	9/10	9/10	6/10
Desirable QIs			
Participants			
1. Attrition rates documented and 30% or below. If severe, comparable across samples?	X		X
Dependent variable/measures			
2. Evidence of test–retest reliability, internal consistency reliability, and interrater reliability (when appropriate) for the outcome measures were provided.	X		X
3. Adequate interscorer agreement is documented.	X		X
4. Data collectors and/or scorers are blind to study conditions and to examinees across study conditions.			X
5. Outcomes were measured beyond an immediate posttest.			X
6. Criterion and construct validity were provided.			X
Independent variable/intervention			
7. Experimental effect replicated across participants, settings, or materials.	X	X	X
8. The nature of services provided in comparison conditions were described and documented.	X	X	X
Results			
9. Actual audio or videotape excerpts were included to capture the nature of the intervention.		X	
10. Results were presented in a clear, coherent, fashion.	X	X	X
Desirable indicators met/Total desirable indicators	6/10	4/10	9/10
NTACT quality	H	H	

Note. H = high quality, met essential QIs 1, 2, 3, 4, 6, 8, 9; 5 or 7; and at least four of the desirable QIs. QI = quality indicator. NTACT = National Technical Assistance Center on Transition.

essential QIs and at least four of the desirable QIs and was adequate quality if it met all essential QIs and at least one desirable QI.

The second task was to determine whether a sufficient quantity of quality studies had been found with an intervention or instructional support of interest. The quality, quantity, and dispersion guidelines outlined by Horner et al. (2005) and NTACT (2015) were used to qualify a practice as evidence-based using single-case design research. An EBP has been defined as one that is (a) based on rigorous research designs, (b) has a record of demonstrated success, and (c) has gone through a systematic review to evaluate the level of evidence using QIs (NTACT). For a practice to be deemed evidence-based using single-case research, it must (a) include a combination of five high or adequate quality single-case studies that used rigorous research designs demonstrating a functional relation, (b) have been conducted across at least three independent research teams in three different geographic areas, (c) include at least 20 participants, and (d) have no studies with negative effects (NTACT). For a practice to be deemed evidence-based using group-experimental investigations, it must (a) include two high quality, or a combination of four high and acceptable quality studies, using rigorous research designs demonstrating positive effects; (b) include calculated effect sizes or reported data that allowed for calculation; and (c) have no evidence of negative effects (NTACT).

Interobserver Agreement (IOA)

The third author served as an independent second rater to provide IOA through each step of the process. First, she independently screened 30% (n = 19/63) of the studies found to determine agreement on meeting inclusion criteria with 100% agreement. Next, the second rater independently coded instructional variables for 39% of the included studies (n = 14/36). The agreement was 91%. Finally, she coded 33% of the included studies (n = 12/36) using the QI checklist, with 98% agreement. A point-by-point method was used to calculate agreement by dividing the number of agreements by the total number of coded items, and then multiplied by 100. Disagreements were discussed until consensus was reached.

Effectiveness of Instructional Interventions

In single-case research, the term *effect size* is attributed to the amount of improvement seen by an individual that can be ascribed to an intervention. Although Browder et al. (2008) used percent of non-overlapping data (PND), its instability due to outlier sensitivity and insensitivity to trend have led the field to explore other, more technically adequate effect size measures (Parker, Vannest, Davis, & Sauber, 2011). Although the field has not come to consensus on which method of determining effect size is most valid or effective, there is emerging evidence that Tau-*U* may be a promising new measure as it is stable and controls for monotonic trends in baseline (Parker et al., 2011; Vannest & Ninci, 2015). Tau-*U* was calculated to determine the effects of single-case interventions when a readable graph of the intervention and baseline was provided. The software UnGraph 5™ (Biosoft, 2004) was used to retrieve the X and Y coordinates from single-case studies with published graphs. The Y coordinates from the baseline and intervention phases were then put into a free web-based Tau-*U* calculator, where data for multiple phase contrasts could be analyzed independently. An effect was calculated (Tau) with control for positive baseline trend (Tau-*U*). Scores can range from −1.0 to 1.0, with a positive score indicating improvement. A 0.20 improvement is a small change, 0.20 to 0.60 a moderate change, 0.60 to 0.80 a large change, and above 0.80 a very large change (Vannest & Ninci, 2015).

Results

Description of the Included Studies

A total of 63 studies were screened for inclusion after the initial search based on reading titles and abstracts, with only 36 of those studies meeting established inclusion criteria. Of these 36 included studies, 33 employed single-case research design methods and three used group-experimental designs. Although some articles included multiple experiments, no article contained more than one mathematics experiment that met inclusion criteria.

A total of 147 participants with moderate and severe developmental disability received mathematics interventions across the 36 included studies. All studies reported gender (female, n = 47; male, n = 100), with the majority of participants being male (68%). The participants represented a variety of disabilities: moderate ID (n = 61; 42%), severe ID (n = 23; 16%), moderate/severe ID unspecified (n = 11; 7%); ASD with moderate ID specified (n = 30; 20%); ASD with severe ID specified (n = 6; 4%); ASD and unspecified intellectual quotients with characteristics of high levels of support needs and/or participated in AA-AAS (n = 11; 8%); and developmental delays with IQ unspecified (n = 5; 3%). Twelve studies included high school or transition-age students aged 15 to 21, 12 studies included middle school–age students, 16 studies included elementary-age students, two studies included preschool students aged 3 to 5, and five studies included more than one age group.

Questions 1 and 2: NCTM Components and Mathematical Skills

A frequency count was conducted of the coded NCTM components and corresponding mathematics skills to answer the first two research questions. The majority of the high quality included studies (*n* = 23; 64%) addressed the NCTM standard of Number and Operations, 11 studies targeted the Algebra standard, seven studies addressed the Measurement standard, five studies targeted the Geometry standard, and only two studies taught skills aligned with the Data Analysis standard. Seven studies addressed more than one NCTM standard (e.g., Creech-Galloway, Collins, Knight, & Bausch, 2013). Table 3 displays the NCTM standards addressed in all high and adequate quality studies.

The Number and Operations skills targeted within the included studies varied widely and represented early numeracy, counting on, calculating a percentage, addition, and subtraction. Early numeracy skills included patterning, making and combining sets, number identification, and counting (e.g., Jimenez & Kemmery, 2013; Skibo, Mims, & Spooner, 2011; Sy & Vollmer, 2012). In all of the studies that focused on counting on from a given number, the participants learned the skill within the context of purchasing (e.g., Cihak & Grim, 2008; Hansen & Morgan, 2008). Various names were used to describe the procedure, including *next dollar, dollar plus*, and *one-more than*. Another consumer skill addressed was calculating a percentage in the context of calculating tax or sales price (e.g., Karl, Collins, Hager, & Ault, 2013). Four studies targeted addition by teaching students to use dot notation method and number lines (Cihak & Foust, 2008; Fletcher, Boone, & Cihak, 2010) and memorization of basic facts (Leaf, Sheldon, & Sherman, 2010; Rapp et al., 2012). Only one study taught subtraction (Bouck, Satsangi, Doughty, & Courtney, 2014).

Skills addressed within the Algebra standard included solving equations (e.g., Browder, Jimenez, & Trela, 2012), analyzing patterns (e.g., Jimenez & Kemmery, 2013), and finding the percent of change within the context of tax or sales price (e.g., Collins, Hager, & Galloway, 2011). Skills addressed within the Measurement standard included telling time (e.g., Falkenstine, Collins, Schuster, & Kleinert, 2009), using nonstandard and standard measurements and calendar skills (e.g., Jimenez & Kemmery, 2013), and concepts such as few, old, long, and thick (Celik & Vuran, 2014). Skills targeted within the Geometry standard included identifying geometric figures (Heinrich, Collins, Knight, & Spriggs, 2016), identifying properties of shapes (Jimenez & Staples, 2015), using the coordinate plane (e.g., Browder, Trela, et al., 2012), and using the Pythagorean Theorem (Creech-Galloway et al., 2013). Finally, only two studies address Data Analysis and targeted interpretation and organization of graphical data (Browder, Jimenez, & Trela, 2012; Browder, Trela, et al., 2012).

Question 3: Comparison of Content and Context

To answer Research Question 3, the percentages of NCTM standards addressed from studies included in this review were compared with those from Browder et al. (2008). Figure 1 shows a comparison of the distribution of standards across studies between 1975 to 2005 and 2005 to 2016. When interpreting Figure 1, it is important to note that all purchasing studies (*n* = 11, 14%) were categorized by Browder et al. into the *Measurement* standard. On the contrary, the current literature review took a different approach based on the NCTM (2000) Principles and Standards description of measurement skills. Ultimately, purchasing skills were bifurcated into either Number and Operations or Measurement, depending on the actual mathematics skill being taught. For example, all interventions that taught counting on using either the next dollar, dollar plus, or one-more than strategies (*n* = 5, 10%) were characterized as Number and Operations because the skill of counting on from a given number falls within that domain. Although the current review spanned a shorter time period (11 years vs. 30 years), had fewer studies (36 vs. 68), and addressed fewer standards (48 vs. 80), the percentages in Figure 1 shows that the scope of content addressed has remained similar. Overall, the majority of interventions in both reviews addressed Number and Operations (see Figure 1).

What has changed in publications over the last decade is an increased focus on Algebra and a decreased focus on Measurement. The number of studies targeting Geometry standards also increased, with a focus on grade-aligned skills such as using the Pythagorean Theorem (Creech-Galloway et al., 2013). Similar to the previous review, the Data Analysis standard was infrequently addressed with two included studies in each review as shown in Figure 1.

The majority of the studies in the current review took place in special education classrooms (*n* = 30; 83%). Some studies conducted a generalization measure in the general education classroom (*n* = 3; 8%) and in the community (*n* = 5; 13%). Several studies took place in other school environments, such as a school common area (*n* = 1; 2%), computer lab (*n* = 1; 2%), and a school bookstore (*n* = 1; 2%). Other settings included clinical settings (*n* = 4; 11%) or a participant's home (*n* = 2; 5%). Ten studies were conducted in multiple settings (27%). These findings did not differ by rank-order from the findings of Browder et al. (2008); however, the proportion of studies did differ, especially in the contextual areas of general education and community, which were reported as 35.8% and 26.9%, respectively, in the previous review, and equated to 8.3% and 13.9% in the present study. The current review did not find any studies that took place in an employment setting or residential facility, whereas Browder et al. (2008) reported 4.5% of their included studies in these contexts.

The current review also analyzed the instructional format and instructor of included studies. Instructional formats included one-to-one (*n* = 24, 66.7%), small group formats of five or fewer students (*n* = 6, 16.7%), whole

Table 3. Participant Information, NCTM Component, Math Skills, and Instructional Practices of High and Adequate Quality Studies With Calculated Tau-*U* Effect Size.

Study	Participants	Age range	Disabilities	NCTM standard	Numbers and operations	Measurement	Algebra	Geometry	Data analyses	Problem solving	Instructional materials	Technology	Graphic organizer	Manipulatives	Instructional methods	Use of task analysis	Massed trials	Explicit instruction	Video Modeling	Systematic Prompting and Feedback	Time Delay	Most to Least Prompts	System of Least Prompts	Simultaneous Prompting	Chaining Procedure	Quality (High or Adequate)	Estimated Effect Size
Birkan (2005)		E, M	Mod ID			X								X			X							X		A	0.99
Bouck, Satsangi, Doughty, and Courtney (2014)		E	ASD		X							X		X									X			H	C: 1 V: .99
Browder, Jimenez, and Trela (2012)		M	Mod ID, Sev ID		X		X	X	X	X			X	X		X							X		X	H	0.88
Browder, Trela, et al. (2012)		H	Mod ID, Sev ID, ASD		X		X	X	X	X			X	X		X							X		X	H	Group
Celik and Vuran (2014)		E	Mod ID			X								X			X	X						X		A	DI: .96 SP: .95
Cihak and Foust (2008)		E	ASD		X								X				X	X					X			A	NL: .47 TP: .97
Cihak and Grim (2008)		H	ASD		X									X			X	X					X			A	0.98
Creech-Galloway, Collins, Knight, and Bausch (2013)		H	Mod ID				X	X		X		X				X	X							X	X	A	1
Falkenstine, Collins, Schuster, and Kleinert (2009)		H	Mod ID			X								X		X	X				X					H	0.85
Fletcher, Boone, and Cihak (2010)		M	Mod ID, ASD		X								X					X					X			A	NL: .83 TP: 1
Hall, Hustyi, Hammond, Hirt, and Reiss (2014)		H	Mod ID, ASD		X							X					X									H	Group
Hansen and Morgan (2008)		H	Mod Id		X							X		X				X	X							H	CBI: 1 Comm: 1
Heinrich, Collins, Knight, and Spriggs (2016)		H	Mod ID				X	X				X				X								X	X	H	D: 1 C: 0.6
Hsu, Tang, and Hwang (2014)		M	Mod ID		X							X		X		X		X					X		X	A	1
Jimenez, Browder, and Courtade (2008)		H	Mod ID				X			X			X	X		X	X				X		X		X	A	0.99
Jimenez and Kemmery (2013)		E	Mod ID, ASD		X	X							X	X							X		X			A	0.93
Jimenez and Staples (2015)		E	Mod ID				X	X					X	X		X					X		X		X	A	0.85
Karl, Collins, Hager, and Ault (2013)		H	Mod ID		X					X		X				X								X	X	H	0.93
Leaf, Sheldon, and Sherman (2010)		P	ASD		X												X							X		H	SP: 0.70 NN: 0.83
Root, Browder, Saunders, and Lo (2016)		E	ASD		X					X		X	X	X		X		X					X		X	A	C: 1 V: 1
Skibo, Mims, and Spooner (2011)		E	Mod ID, Sev ID		X												X						X			A	0.91
Sy and Vollmer (2012)		P, E	DD		X			X									X									A	IM: 1.1 D: 0.005
Thompson, Wood, Test, and Cease-Cook (2012)		E	Mod ID, ASD			X								X				X								H	0.5
Tzanakaki, Hastings, Grindle, Hughes, and Hoare (2014)		E	ASD, Sev ID		X									X			X	X								H	Group
Weng and Bouck (2016)		M	Mod ID		X							X	X	X		X					X		X		X	A	C: 0.84 V: 0.89

Note. Please see group study articles for effect size measurements for each dependent variable. Age range codes: P = preschool; E = elementary; M = middle school; H = high school/transition. Disabilities codes: Mod ID = moderate intellectual disability; Sev ID = severe intellectual disability; ASD = autism spectrum disorder; DD = developmental delay. Quality codes: A = adequate quality; H = high quality. Estimated effect size codes: C = concrete; V = virtual; DI = direct instruction; SP = simultaneous prompting; NL = number line; TP = touch points; CBI = community-based instruction; C = community probe; D = discrete task; C = chained task; NN = no-no prompting; IM = immediate reinforcement; D = delayed reinforcement. NCTM = National Council of Teachers of Mathematics.

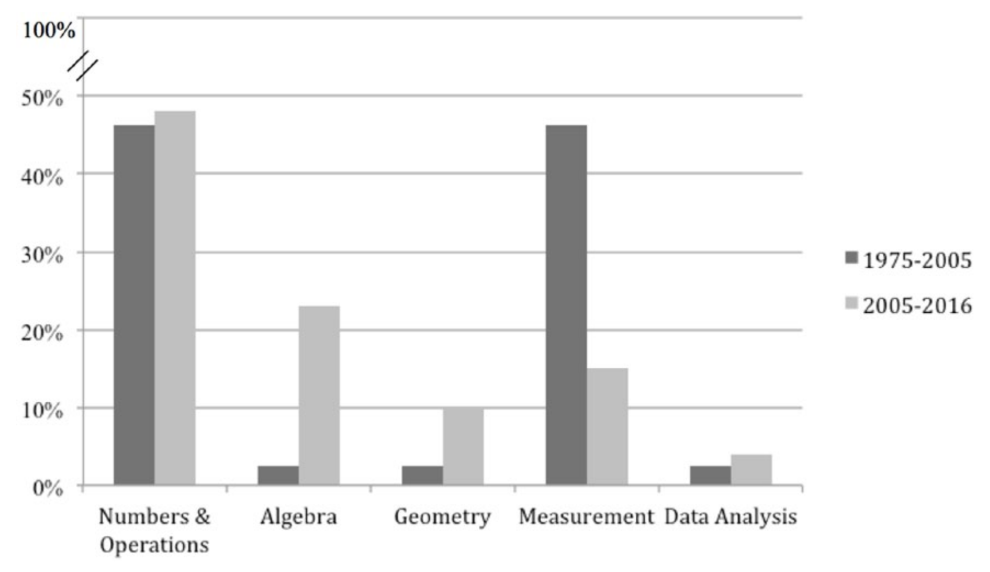

Figure 1. Comparison of findings by NCTM standard.
Note. The total number of NCTM standards addressed were analyzed for Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008; *n* = 80) and the present study (*n* = 48). The percentages of these addressing each individual standard were calculated due to the uneven number of total studies to give a true representation of the spread. NCTM = National Council of Teachers of Mathematics.

Table 4. Mean and Range Tau-*U* Values and Qualifying Criteria for Evidence-Based Practices in Single-Case Research.

Evidence-based instructional practice	*M* Tau-*U*	Tau-*U* range	Total no. of studies	No. of research groups	No. of geographic locations	No. of participants
Systematic instruction	.92	.6–1	19	9	8	62
Technology-aided instruction	.94	.6–1	9	6	6	35
Graphic organizer/heuristic	.89	.47–1	8	6	4	27
Manipulatives	.92	.84–1	14	11	7	45
Explicit instruction	.90	.47–1	8	6	5	26

group or class setting (*n* = 3, 8.3%), or a combination of one-to-one and small group (*n* = 3, 8.3%). A variety of instructors were used in the included studies: 21 with the teacher as the instructor (58%), 10 with the researcher as the instructor (28%), and five with a combination (14%; teacher/paraprofessional: *n* = 3; teacher/researcher: *n* = 1; teacher/peer tutor: *n* = 1). This was not aggregated in Browder et al. (2008).

Question 4: EBPs

To address Research Question 4, we used the NTACT (2015) guidelines for classifying single-case and group-experimental research as "high" or "adequate" quality, based on the indicators set forth by Horner et al. (2005) and Gersten et al. (2005). From the single-case analysis, eight single-case studies were deemed high quality and 14 were adequate quality as shown in Table 1. Only three group-experimental studies were found (Browder, Trela, et al., 2012; Hall, Hustyi, Hammond, Hirt, & Reiss, 2014; Tzanakaki, Hastings, Grindle, Hughes, & Hoare, 2014) and all three were deemed high quality as shown in Table 2.

To determine the extent to which the included studies used established EBP (e.g., systematic instruction), as well as to investigate potential additional EBPs, instructional variables used in high and adequate quality studies were examined. The three high-quality group studies reported moderate to large effect sizes; however, no two group studies utilized the same instructional practices to meet the standards for establishing an EBP in mathematics at the group-design level. The calculated effect sizes for high and adequate quality single-case design studies for each intervention are shown in Table 3. The information for qualifying each practice as an EBP (i.e., number of studies, research group, locations, and participants) and calculated mean Tau-*U* and ranges for the identified EBP are reported in Table 4 (see Table 4).

Systematic instruction (e.g., time delay, system of least prompts, most-to-least prompts, simultaneous prompting, stimulus prompting/fading, and use of a chaining procedure) previously was determined to be an EBP in Browder et al. (2008). Systematic prompting was used in the majority of high and adequate quality single-case design studies in the current review (19 of 22, 86%) and included 62 participants with moderate and severe disabilities, across nine research teams in eight geographic areas.

The second EBP identified was Technology Aided Instruction (TAI). Nine of the included high and adequate quality studies used TAI, defined as any electronic item/equipment/application or virtual network that is used intentionally to increase/maintain, and/or improve, daily living, word/productivity, and recreation/leisure capabilities that plays a central feature of an intervention that supports the goal or outcome for the student (Odom et al., 2015). These nine high and adequate studies that used TAI included 35 participants with moderate and severe disabilities, and were conducted across six research teams in six geographic areas. Algebra, Number and Operations, and Geometry NCTM standards were addressed. Different technological devices were used in the studies, including a computer (e.g., Hall et al., 2014), a tablet (e.g., Hsu, Tang, & Hwang, 2014) and a calculator (e.g., Creech-Galloway et al., 2013).

A third EBP was graphic organizers, which were defined specifically for mathematics as a diagram that shows the relative positions of the elements and their relationships to one another to help students conceptually understand and solve a problem (Ives & Hoy, 2003). A total of eight of the included high and adequate quality studies used graphic organizers with 27 participants with moderate and severe disabilities, and were conducted across six research teams in four geographic locations. All five NCTM standards were addressed. Studies used a number line that supported the procedural solving of mathematical problems (e.g., Fletcher et al., 2010), or more complex graphic organizers related to specific problems where manipulatives could be used to solve problems on them (e.g., Root, Browder, Saunders, & Lo, 2016).

A fourth EBP was the use of manipulatives, defined as concrete or virtual objects that aid students in understanding and solving abstract mathematical concepts and problems (Bouck et al., 2014). A total of 14 of the included high and adequate quality studies included manipulatives with 45 participants with moderate and severe disabilities, and were conducted across 11 research groups in seven geographic areas. All five NCTM standards were addressed. The type of manipulatives used varied, including clocks (e.g., Birkan, 2005), money (Hsu et al., 2014), concrete counters (e.g., Jimenez & Staples, 2015), and virtual counters (Bouck et al., 2014).

Finally, explicit instruction was found to be an EBP for teaching mathematics for students with moderate and severe disability. Explicit instruction is defined as a series of supports and scaffolds where students are guided through the learning process in small steps with clear explanations and demonstrations of the targeted skill and provided with practice with feedback until mastery is achieved (Archer & Hughes, 2011). A total of eight of the included high and adequate quality studies included explicit instruction with 26 participants with moderate and severe disabilities, and were conducted across six research groups in five geographic areas. Number and Operations and Measurement NCTM standards were addressed. The explicit instruction strategy used most frequently was model, lead, test (e.g., Cihak & Foust, 2008), although direct instruction (e.g., Thompson, Wood, Test, & Cease-Cook, 2012) and example/nonexample training (e.g., Celik & Vuran, 2014) also were used.

Discussion

Focus of Mathematical Content

The primary purpose of this review was to analyze the literature on teaching mathematics to students with moderate and severe developmental disability between 2005 and 2016, directly extending the work of Browder et al. (2008). Overall, research on mathematics for students with moderate and severe developmental disability has increased in frequency with 3.2 studies per year as compared with 2.7 per year in the prior review. The scope of content reviewed also has had modest expansion. For students to be prepared for state alternate assessments, all strands of mathematics in the targeted grade level must be addressed but at a reduced level of complexity (Quenemoen & Thurlow, 2015). A point of concern in the prior literature reviews has been the focus on discrete skills and the need to build higher order thinking skills to address the conceptual development of mathematics content (Browder et al., 2008; Hart Barnett & Cleary, 2015; Lemons et al., 2015). When considering grade-aligned mathematics standards, this is important because the skills targeted increase in difficulty across grade levels (Hart Barnett & Cleary, 2015; Quenemoen & Thurlow, 2015). Recent studies offer models of interventions for teaching simplified content related to grade-level standards (e.g., Geometry, Creech-Galloway et al., 2013; Algebra, Jimenez, Browder, & Courtade, 2008).

Although the expansion in scope of content was limited, there was progress in demonstrating ways to teach students with moderate and severe developmental disability problem solving. Teaching students to solve problems with themes related to their everyday life experiences helps them know when and why to apply their emerging mathematical strategies, rather than just teaching them to compute numbers out of context. Within both the NCTM and CCSSM, practical applications of mathematics are emphasized and educators are encouraged to embed functional skills within mathematical learning (National Mathematics Advisory Panel, 2008). For example, the NCTM's process standards of problem solving and reasoning (which are also including in the CCSSM *Standards for Mathematical Practice*) require students to complete practical application problems, which further encourage students' independence and self-determination skills. In the prior review, there was only one study that targeted problem solving (Neef, Nelles, Iwata, & Page, 2003). In the current review, multiple studies were identified with a problem-solving focus (e.g., Browder, Trela, et al., 2012; Creech-Galloway et al., 2013; Jimenez et al., 2008; Root et al., 2016).

Changes in Context for Mathematics Instruction

We considered whether the context for investigations on mathematical learning changed in the past decade. Although Browder et al. (2008) found in vivo instruction to be an EBP, studies in the current review were not commonly conducted in community contexts. One reason for this change is more studies in the earlier review were teaching functional life skills that had some mathematical response (e.g., finding the price), whereas studies conducted in the past decade had more of a focus on mathematical learning aligned with academic standards. Generalization of mathematical skills to authentic contexts is a crucial component of learning, especially for secondary students. Although the studies focused on more mathematical learning (as opposed to life skills), there was not an increase in the number of studies conducted in inclusive, general education settings (e.g., Heinrich et al., 2016; Jolivette, Lingo, Houchins, Barton-Arwood, & Shippen, 2006). More studies are needed to model how to embed the mathematical learning of students with moderate and severe developmental disability within general education contexts. This might include embedding systematic instruction by a peer or special educator or using classwide strategies like cooperative learning groups or assistive technology to make the content more accessible to all students.

Another change in the context of instruction in the current literature was the increased use of small and whole group formats, which can provide the opportunity for observational learning as peers respond. What is needed are more examples of mixed-ability groups in which the student with moderate and severe disability participates with peers who are nondisabled are needed. Although peer instruction has been found to be effective for students with moderate and severe disability (e.g., Jameson, McDonnell, Polychronis, & Riesen, 2008), only one study used peers to support mathematical learning (Heinrich et al., 2016).

Inferences of EBPs

The final question we asked of this body of research is what EBPs emerged. Overall, this review adds to the evidence presented by Browder et al. (2008) that students with moderate and severe developmental disability can learn mathematical content and provides emerging evidence that these students can learn content that aligns with their grade level, including problem solving. Tau-*U* revealed strong effects across high and adequate quality single-case studies that evaluated the effects of identified EBPs.

There were sufficient studies of high and adequate quality and overall strong effects to be able to make some inferences about both the practices and content taught. The current review adds to the support of Browder et al. (2008) that systematic instruction strategies effectively can be applied to teaching mathematics content. These strategies were not only used in studies with a life skills focus (e.g., Hansen & Morgan, 2008) but also in studies with an academic focus (Creech-Galloway et al., 2013; Jimenez et al., 2008). The current review also provides support for four new EBPs for teaching mathematics to learners with moderate and severe developmental disability including technology-assisted instruction, the use of manipulatives, graphic organizers, and explicit instruction. As seen in Table 3, these EBPs represent both instructional methods and materials; therefore, all studies evaluated an intervention that was comprised of more than one EBP. All studies generally used an instructional method (e.g., explicit instruction) as well as a material (e.g., manipulatives), also known as a treatment package. More frequently, treatment packages consisted of multiple methods and materials, such as a task analysis, systematic instruction, graphic organizers, and manipulatives (e.g., Browder, Jimenez, & Trela, 2012; Browder, Trela, et al., 2012; Root et al., 2016).

The increase in technology-assisted instruction may reflect the overall increase in the use of technology in all aspects of 21st-century society. There also is evidence that technology-assisted instruction may be especially beneficial for teaching academics to students with ASD (Knight, McKissick, & Saunders, 2013; Root, Stevenson, Davis, Geddes-Hall, & Test, 2017). The use of manipulatives also is understandable, because as teachers increase instructional focus on the conceptual understanding of mathematics, manipulatives become more critical for students to gain understanding by moving from the concrete level of understanding to the abstract. Similarly, the use of graphic organizers can help students organize critical information to aid in problem solving, thus helping build conceptual understanding as well. Finally, the use of explicit instruction can provide mathematics instruction on more advanced concepts in a scaffolded manner with modeling and guided practice.

Needs for Future Research

Although the research on mathematics instruction for students with moderate and severe disability continues to expand, there remain many unanswered questions. Given the importance of teaching students to be problem solvers, it is concerning that more studies are not using a problem-solving approach. By only focusing on the procedures like computation, and not the underlying processes, students learn "how" but not "when" or "why" to use the skills acquired. More information is needed on how to teach the expanded scope of content students with moderate and severe developmental disability are expected to learn as reflected in alternate assessments (Lee et al., 2016).

One way to expand the content of focus in research is by replicating promising practices used with students with high-incidence disabilities and adapting them to include more EBP for low-incidence disabilities (e.g., systematic instruction and repeated opportunities for practice). For example, schematic diagrams, an effective practice for high-incidence disabilities, also have been adapted for students with moderate and severe disability (e.g., Root et al., 2016). Research designs that allow for comparison of instructional methods or component analyses may positively contribute to this endeavor as well, given the frequent use of treatment packages in this study. It is important to understand the instructional factors to which learning should be attributed. Considering the motivation of the EBP movement was to identify "what works for whom, under what conditions"; future research on these practices that identifies whether effects differ based on student characteristics (e.g., disability, age, pre-skills, etc.) is warranted.

There remains a need to build a progression of skills for this population. In the current review, three studies provided examples for doing so by using an early numeracy curriculum to teach a progression of foundational mathematics skills (Hudson, Zambone, & Brickhouse, 2016; Jimenez & Kemmery, 2013; Jimenez & Staples, 2015). More information is needed on how students respond to comprehensive, sequential curriculum that builds a progression of skills. Such a sequence might be derived from general education standards. For example, the National Center and State Collaborative (NCSC; 2015) provided examples of learning families derived from the Common Core State Standards that can be used to plan instruction both within and across school years (https://wiki.ncscpartners.org).

Although the need to assess, and if needed, teach generalization has been a long-recognized characteristic of effective instruction for this population, only 22 of the 36 studies had any type of generalization measure. Future research needs to include at least two types of generalization. The first is to show conceptual understanding by varying the numbers and other aspects of the specific problem solved. Studies also should indicate the modifications made that place parameters on generalization (e.g., only using numbers under 20). The second type of generalization needed is to show students can apply skills in context. Although ideal, this might not be implemented in a community setting. Instead, generalization may involve setting up an authentic activity in the school environment or using video examples of authentic contexts to see if the student then can apply mathematical learning.

Another area of future research is to continue expanding the array of both EBPs and content. For example, graphic organizers were broadly defined in this study, including both number lines and diagrams used for problem solving, but additional studies are needed to replicate the use of number lines and diagrams for problem solving to deem them as EBP individually. Strategies like Concrete–Representational–Abstract that have been found to be effective with other populations (Gersten et al., 2009) also might be applied, especially to address a wider range of and more complex content. There also needs to be more studies on higher level thinking skills in mathematics, moving beyond discrete skills and chained tasks solved solely by rote procedures. Finally, the relative paucity of investigations of mathematical learning in inclusive settings warrants future research into effect and feasible methods for students with moderate and severe disability to learn general education content in general education settings.

Limitations

There are some notable limitations in this review. As with other reviews, there is a chance that additional research has been conducted in this area that has not been published, and therefore is not available to be included this review. Also, despite considerable effort on the part of the authors, one or more studies may have been overlooked. Although Tau-*U* was used to calculate sizes for high and adequate quality studies, we did not conduct a meta-analysis or calculate omnibus effect sizes. Information about moderating and mediating variables, such as individual ID severity or race, could be answered in further analyses of specific practices that were identified in this article as evidence-based.

Although we identified practices used in the included studies as evidence-based, many were part of treatment packages that included a combination of these separate practices. For example, graphic organizers were almost always used with systematic instruction and manipulatives (e.g., Browder, Trela, et al., 2012; Jimenez & Staples, 2015). The limitation in evaluating practices that are within a treatment package is that without a sufficient number of component analyses, the impact of each individual practice in isolation is unknown.

Finally, the EBPs identified in this review were found to be effective in teaching a broad range of mathematical skills. Although these findings assist practitioners and the field as a whole in selecting effective instructional strategies to teach mathematics to students with severe disability, the question of "what works for whom under what conditions" still remains. When considering "for whom," this review spanned a wide age (5–21) and ability range. Relatedly, this review broadly analyzed mathematical outcomes as a whole when considering whether practices had sufficient quantity of quality evidence to support designation as an EBP, and did not analyze the evidence by mathematical domains or skills.

Implications for Practice

Practitioners can glean implications for both what and how to teach from this review. In mathematics, students need to learn both a progression of foundational skills (e.g., early numeracy) and how to apply these within the content of their assigned grade levels. It is this application to the grade-level content that typically is the focus of alternate assessments (Quenemoen & Thurlow, 2015). These students need instruction that focuses on foundational mathematics skills, such as number sense, while applying these skills to grade-aligned problems for elementary students. Secondary students may benefit from mathematics instruction on simplified grade-aligned content, such as a smaller portion of the content, using smaller numbers, or teaching a simple version of a skill.

Once content is selected, practitioners need to choose EBPs that match both the content and student's needs. These instructional practices are almost never used in isolation; decisions must be made about both the instructional strategies and supports students will need to make progress in mathematics. The two broad categories of evidence-based instructional practices highlighted in this review were systematic and explicit instruction. Often, mathematical procedures can be task analyzed and taught using systematic prompting with feedback, EBPs that were spotlighted by Browder et al. (2008) and further supported by the current review. Task analysis can be especially helpful in longer chained tasks, such as word problems. Conversely, explicit instruction may be needed for teaching some concepts, such as more/fewer, long/short, or same/different through presentations of many examples and nonexamples that sample a broad range of stimuli for each concept.

Several evidence-based instructional supports were established in this review, including graphic organizers, manipulatives, and TAI. Graphic organizers can be used to help students understand the relationship between numbers and quantities, especially within problem-solving contexts. Manipulatives may benefit students when learning to procedurally solving problems with graphic organizers, such as by making and combining sets of quantities from a word problem onto a graphic organizer to visually represent "what is happening." Finally, TAI may be useful for helping students compensate for procedural deficits, such as through calculator use and anchoring instruction within authentic contexts through video clips as well as providing opportunities for simulated instruction.

Summary

In the prior review, Browder et al. (2008) concluded that students with moderate and severe disability can learn mathematical content, but the extent of this learning had been limited to computational skills. Unfortunately, the emphasis on computing numbers without necessarily addressing context continues to be prevalent in research with this population. Studies in the last decade have provided the first set of studies on how to teach more complex problem solving in which authentic "stories" provide a context for mathematical learning. More studies also have been added addressing other domains, such as Algebra and Geometry. Future research is needed to show how students can build a progression of skills, generalize their conceptual learning to authentic applications, and learn the broad scope of content teachers already must introduce for today's alternate assessments. What is not yet known is how much mathematics students with moderate and severe disability can learn and how this learning will open future life opportunities.

Authors' Note

The opinions expressed do not necessarily reflect the position or policy of the Department of Education, and no official endorsement should be inferred.

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