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Effective Mathematics Instruction for Students With Moderate and Severe Disabilities: A Review of the Literature

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Abstract

Educational programs for students with moderate and severe disabilities (MSD) have undergone drastic changes since the mandate for access to the general curriculum was provided by Individuals With Disabilities Education Act. Since then, educators have struggled to find methods to use to promote optimal learning, including in the area of mathematics. The purpose of this systematic literature review was to provide an update on research related to teaching mathematics to students with MSD published from 2005 to 2017. Results from the included studies indicated that mathematics research has started to diversify in the skills that are being taught to this population. In addition to skills taught, current research has continued to inform the field on some promising methods that can be used to teach a broader range of mathematics skills. Emerging strategies that were identified included the use of concrete representations, anchored instruction, and instructional technology. Suggestions for future research are discussed.

Keywords

mathematics, instruction, access to the general curriculum, intellectual disability, autism, moderate disability, severe disability, concrete representations, manipulatives, anchored instruction, math stories, in vivo, systematic instruction, technology

The Individuals With Disabilities Education Act (IDEA; 2004) requires that all students with disabilities participate and progress in general education curriculum particularly in the areas of language arts, mathematics, and science. Research over the last decade has shown that students with moderate and severe disabilities (MSD) can acquire a wide range of academic skills when they are provided with explicit and systematic instruction (McDonnell & Hunt, 2014; Spooner, Knight, Browder, & Smith, 2012).

Several recent studies have demonstrated that students with MSD can learn complex mathematics concepts and operations using evidenced-based special education practices such as task analytic instruction, response prompting and fading, and visual supports (Creech-Galloway, Collins, Knight, & Bausch, 2013; Heinrich, Collins, Knight, & Spriggs, 2016; Jimenez, Browder, & Courtade, 2008; Root, Browder, Saunders, & Lo, 2017). For example, Jimenez et al. (2008) taught three high school students with MSD to solve for x in an equation using task analytic instruction with time delay. Similarly, Creech-Galloway et al. (2013) taught four adolescents with MSD to apply the Pythagorean theorem to solve problems using video-based mathematics stories and simultaneous prompting.

Earlier reviews focused on teaching math to students with MSD had found that the majority of studies focused on a relatively narrow range of core mathematics standards (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; Spooner et al., 2012). Browder and colleagues (2008) reviewed 68 studies teaching math skills to students with significant cognitive disabilities published from 1975 to 2005. Part of their review focused on the extent to which the mathematics skills taught in these studies aligned with the National Council of Teachers of Mathematics (NCTM) content standards. While they found that all NCTM content standards were represented in the studies, only six of the

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studies (8%) fell outside of numbers and operations and measurement. Standards receiving limited representation included algebra, geometry, and data analysis/probability. Further-more, the studies that addressed skills described within the numbers and operations and measurement standards focused on basic skills such as counting, matching, money, and time.

The NCTM (2000) asserts that high-quality mathematics instruction requires that all students have access to all content standards in each grade band to cumulatively develop complex conceptual and computational skills as they progress in school. In addition, a fundamental assumption underlying the IDEA (2004) is that students with disabilities will have equal access to instruction on core content standards. This begs the question of what progress has been made in the last decade and a half in developing and validating instructional approaches and strategies that allow students with MSD to access the full range of mathematics concepts, operations, and skills in the core curriculum.

The purpose of the present review is twofold. First, the review will seek to determine whether research studies focused on teaching mathematics to students with MSD since 2005 have broadened the range of skills targeted for instruction to address more of the NCTM content standards. Second, the review will identify the promising practices for teaching complex mathematics content to students with MSD.

Method

Literature Search Procedures

A variety of terms and combinations of terms were used to identify the current research base for teaching mathematics to students with MSD. These terms were obtained from mathematics standards, that is, add*, subtract*, multiply*, divide, division, money, time, probability, graph*, count*, math*, and STEM (science, technology, engineering, and math) as well as terms embedded within the NCTM content standards (i. e. numbers, operations, geometry, algebra, data analysis, probability, and measurement). These terms were then combined with each term that could be used to describe students with MSD in the literature (e.g., intellectual disability [ID], severe disability, autism, and mental retardation). The total number of combinations of terms used to search the electronic database was 76.

This literature review sought to identify research studies focused on teaching mathematics concepts, operations, and skills from the general education curriculum to students with MSD following the passage of IDEA 2004 through March 2017. The electronic database Education Full Text + ERIC and PsycINFO were searched. In addition to electronic searches, hand searches of prominent special education journals were also conducted including *Education and Training in Autism and Developmental Disabilities, Exceptional Children, Intellectual and Developmental Disabilities, Research and Practice for Persons With Severe Disabilities, Remedial and Special Education*, and *The Journal of Special Education*.

Inclusion Criteria

For a study to be included in the review, it needs to (a) be published in a peer-reviewed journal between January 2005 and March 2017; (b) include at least one subject with an IQ of less than 60 or who was reported eligible for the alternate assessment between the ages of 5 and 21; (c) have an intervention designed to improve mathematics skills and report firsthand data; (d) use a single-subject research design demonstrating experimental control; and (e) meet the Horner et al. quality indicators for single-subject research design. The original search of the electronic database and hand searches identified a total of 51 studies. Following the initial search, the study pool was narrowed to single-case studies because of the small number of group design studies (two identified). In addition, seven articles were excluded because they did not report an IQ score or the IQ scores did not fit the criteria of this study (<60); another six assessed skills that were not related to mathematics, the participants did not reach mastery on the mathematics skill, or the mathematics skill was graphed in conjunction with a non-mathematic skill; five included participants who were not school-aged or were focused on the skills of the teacher; four were not experimental (they were either a review or a practitioner article); and one did not demonstrate experimental control. Two articles were included in the review that did not indicate an IQ score for participants only because there were other indications that the participants had MSD (such as eligibility for their state's alternate assessment). Two were excluded because they did not meet minimum quality standards set forth by Horner et al. (2005). Remaining was a total of 24 studies that were included in this review (see a summary of the studies provided in Table 1).

Coding

The NCTM (2000) has developed five content standards to describe the mathematics skills all students should have as a result of high-quality mathematics instruction. The content standards include (a) numbers and operations, understanding numbers, operations, and computing fluently; (b) algebra, understanding patterns, number relationships, and functions; (c) geometry, analyzing characteristics of geometric shapes and their relationships; (d) measurement, understanding the measurable aspects of objects and the units and process of measurement; and (e) data analysis and probability, the ability to develop questions, collect and analyze data to answer those questions, and use data to

Table 1. Studies on Teaching Math to Students With MSD From 2005 to 2017.

Study	IQ score	Setting	Content	Dependent variable	Independent variable
Ayres, Langone, Boon, & Norman, 2006	38–58	S, C	N	Duration and accuracy of purchasing exchange	Computer-based instruction
Bouck, Park, & Nickell, 2017	56–92	S	N	Change-making with coins problems	CRA instructional sequence
Browder, Jimenez, & Trela, 2012	30–41	S	A, G, D, M	Math unit assessment probe	Math stories, concrete representations, task analytic instruction
Browder, Jimenez, Spooner, et al., 2012	42–55	S, G	N, A, G, M	Curriculum-based assessment	Embedded instruction, math stories, concrete representations
Cihak & Foust, 2008	40–50	S	N	Single-digit addition problems	Number line, touch points
Cihak & Grim, 2008	35–50	S, C	N	Purchasing exchange	Counting on strategy
Creech-Galloway, Collins, Knight, & Bausch, 2013	41–57	S	G	Solving for an unknown side of a triangle	Simultaneous prompting, task analytic instruction, iPad simulation
Everhart, Alber-Morgan, & Park, 2011	NC	S	N	Number identification	Computer-based instruction
Falkenstine, Collins, Schuster, & Kleinert, 2009	42–52	S	M	Telling time and setting the time on a wristwatch	Instructive feedback and observational learning
Fletcher, Boon, & Cihak, 2010	40–45	S	N	Single-digit addition problems	TOUCHMATH program and the use of number lines
Hansen & Morgan, 2008	45–55	G, C	N	Number identification	Multimedia computer-based instruction
Heinrich, Collins, Knight, & Spriggs, 2016	47–56	G	G, A	Solving a linear equation and identifying geometric figures	Simultaneous prompting
Hudson, Zambone, & Brickhouse, 2016	50	S	N, A, M	Early numeracy assessment	Systematic instructional package with individualized adaptations (AAC, manipulatives)
Jimenez, Browder, & Courtade, 2008	41–49	S	A	Solving for x in an algebraic equation	Concrete representations, task analytic instruction, systematic prompting and fading
Jimenez & Kemmery, 2013	NC	S	N, A, M	Early numeracy skills	Math story problems, systematic instruction, graphic organizers, multiple exemplars
Jimenez & Staples, 2015	40–45	S	A, G	Early numeracy skills	Theme-based lessons, systematic instruction, concrete representations
Rao & Kane, 2009	47–50	S	N	Subtraction problems	Simultaneous prompting
Rao & Mallow, 2009	47–62	S	N	Multiplication facts	Simultaneous prompting
Root, Browder, Saunders, & Lo, 2017	46–62	O	N, A	Math word problems	Modified schema-based instruction
Root, Saunders, Spooner, & Brosh, 2017	42–47	S	N	Personal finance word problems	Modified schema-based instruction
Sheriff & Boon, 2014	59–65	S	N	One-step word problems completed	Computer-based graphic organizers
Skibo, Mims, & Spooner, 2011	20–44	S	N	Number identification	Response cards, least to most prompting
Strozier, Hinton, Flores, & Terry, 2015	55–73	O	N	Addition and subtraction with regrouping and multiplication problems	CRA instruction, base 10 blocks model, model-lead-test
Yakubova & Bouck, 2014	57–68	S	N	Solving word problem	Use of scientific and graphic calculators

Note. MSD = moderate and severe disabilities; IQ = intelligence quotient; NC = not clear; Setting (S = special education; G = general education; C = community, O = other); Content (N = numbers and operations, A = algebra, G = geometry, M = measurement, D = data analysis/probability); CRA = concrete–representational–abstract.

make predictions and understand probability (NCTM, 2000). The target skills from each study were coded to identify the NCTM standards that they would be included.

Individual studies were also coded to identify study characteristics, quality, and systematic instructional components. Other study characteristics coded included (a) the number of participants, their ethnicity, gender, IQ and special education eligibility category; (b) the setting (E—elementary school, M—middle school, H—high school, S—special education classroom, G—general education classroom, C—community, and O—other), (c) the NCTM standard addressed (N—numbers and operations, A—algebra, G—geometry, M—measurement, and D—data analysis and probability), (d) the dependent variable, (e) the independent variable, and (f) whether maintenance and generalization were assessed (Y = yes, N = no). The included studies with a summary of their characteristic codes are listed in Table 1.

This review also analyzed the studies to determine the types of instructional format (i.e., in vivo, total task chaining, spaced trial, or massed trial), the methods of prompting and prompt fading (least to most, most to least, time delay, simultaneous prompting, or model-lead-test), and whether systematic error correction strategies were used with students during instruction. A summary of these instructional components is displayed in Table 2.

To determine the quality of the studies, indicators developed by Horner et al. (2005) were utilized. The analysis focused on seven standards including a replicable description of the participants and settings, a replicable description of the dependent variable(s), a replicable description of the independent variable(s), collection of baseline data, demonstration of experimental control of the primary dependent variable(s), demonstration of external validity, and demonstration of social validity. Nineteen studies (79%) met all of the quality indicators (21 out of 21), and five (21%) studies met most of the quality indicators (defined as 20 out of 21).

Interrater Reliability

Interrater reliability was established for the quality indicators and characteristics of five of the 24 studies (21%). The first, third, and fourth authors completed the initial coding for each study, and the second author independently coded the five studies for reliability. Each component of quality and characteristics was compared item by item to determine the rate of agreement. Interrater reliability was calculated by dividing agreements by agreements plus disagreements and multiplying by 100. For study characteristics, interrater reliability was 94% (range = 90%–100%). Systematic instructional components were coded with 96% reliability (range = 90%–100%). Finally, the quality of the studies had 94% interrater reliability (range = 81%–100%). Mean interrater reliability was 94%. Following the ratings, disagreements were noted and discussed between the initial coder and the second author until consensus was reached. The consensus coding was used in the analysis of the studies included in the review pool.

Results

Study Characteristics

The 24 studies included in the review had a total of 67 participants with an IQ less than 60, or who were reported as eligible for their state's alternate assessment. Of the 24 studies, 72% (18) reported the gender of each participant, and 42% (10) reported the race or ethnicity of each participant. Of those who reported, 69% of participants were male and 31% were female. Of the studies who reported race and ethnicity of the participants, 48% (14) were Caucasian, 28% (eight) were African American, 21% (six) were Hispanic/Latino, and 3% (one) was Jordanian. Participants' disability classifications varied, but the most common included moderate ID (36%), ID (21%), and moderate ID and autism (18%). Ten (42%) of the studies were conducted in an elementary setting, eight (33%) in a middle school setting, and six (25%) in a high school setting. The majority of the studies (n = 18; 75%) occurred in a special education classroom or setting and one (4%) was conducted in a general education setting. Three (13%) were conducted in a combination of settings, one (4%) in a self-contained setting and the community, one (4%) in a computer lab and the community, and one (4%) in a self-contained and general education setting. Three of the studies were done in other settings (i.e., hallway, researcher's home, tutoring room).

NCTM Standards

There were 18 (75%) studies that taught skills related to numbers and operations. Skills taught within the numbers and operations content standard included making change with coins, counting objects, identifying numbers, multiplication facts, one-step word problems, and addition and subtraction with regrouping. Nine (38%) studies taught skills related to algebra, including finding an unknown quantity, identifying patterns, extending ABAB patterns, and solving linear equations. Five (21%) studies taught skills related to geometry, including drawing line segments, identifying shapes, and calculating the unknown side of a triangle. Six (25%) studies taught skills related to measurement, including measuring objects using standard and nonstandard units and telling time. Finally, one (4%) study taught skills related to data analysis/probability, that included skills such as recording data from a story and using data to solve a problem. Eight (33%) studies involved two or more NCTM content standards which contributed greatly to the diversity of the skills represented.

Instructional Strategies

Twenty-three (96%) of the studies were explicit in describing an instructional format (such as in vivo instruction) and 23 (96%) of the studies utilized systematic prompting and fading strategies (such as least-to-most prompting). The format of instruction described within each study varied. Three (13%) studies used in vivo instruction, 18 (75%) used total task chaining, five (21%) used spaced trials, and eight (33%) used massed trial instruction. Systematic prompting

Table 2. Systematic Instructional Components Included in Each Study.

	Ayres, Langone, Boon, & Norman, 2006	Bouck, Park, & Nickell, 2017	Browder, Jimenez, & Trela, 2012	Browder, Jimenez, Spooner et al., 2012	Cihak & Foust, 2008	Cihak & Grim, 2008	Creech-Galloway, Collins, Knight, & Bausch, 2013	Everhart, Alber-Morgan, & Park, 2011	Falkenstine, Collins, Schuster, & Kleinert, 2009	Fletcher, Boon, & Cihak, 2010	Hansen & Morgan, 2008	Heinrich, Collins, Knight, & Spriggs, 2016	Hudson, Zambone, & Brickhouse, 2016	Jimenez, Browder, & Courtade, 2008	Jimenez & Kemmery, 2013	Jimenez & Staples, 2015	Rao & Kane, 2009	Rao & Mallow, 2009	Root, Browder, Saunders, & Lo, 2017	Root, Saunders, Spooner, & Brosh, 2017	Sheriff & Boon, 2014	Skibo, Mims, & Spooner, 2011	Strozier, Hinton, Flores, & Terry, 2015	Yakubova & Bouck, 2014
In vivo	X					X					X													
Total task		X	X	X			X		X	X	X	X	X	X	X	X	X		X	X	X		X	X
Spaced trial			X	X											X							X	X	
Massed trial		X						X	X	X			X					X			X			X
Least-to-most			X	X	X	X		X		X			X	X	X	X			X	X		X		
Time delay	X			X					X		X		X	X	X	X								
Model-lead-test		X			X					X									X	X			X	X
Simultaneous							X					X					X	X						
Error correction	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	NC	Y	Y	N

Note. X = component was present; Y = yes; N = no; NC = not clear; N/A = not applicable.

and fading strategies also varied among the studies. Thirteen (54%) used least-to-most prompting, none used most-to-least, eight (33%) used time delay, seven (29%) used model-lead-test, and four (17%) used simultaneous prompting (see Table 2).

In addition to the use of commonly accepted evidenced-based instructional practices, a number of the studies also used instructional methods and approaches that sought to make the concepts and operations less abstract and more relevant to students' daily lives. These practices included concrete representations, anchored instruction, and embedding technology. Eleven (46%) of the studies included in the present review included some type of concrete or visual representation to support students in acquiring mathematical knowledge and skills. Concrete representation is defined in this review as the use of manipulatives (i.e., base 10 blocks, counting bears, poker chips) and/or graphic organizers (i.e., part-part-whole chart, arrays, tree diagrams) that enable students to learn mathematics concepts visually. Concrete representations have been a consistent strategy utilized by general education teachers as well as teachers serving students with high-incidence disabilities, including autism (What Works Clearinghouse, 2012; Yakubova, Hughes, & Shinaberry, 2016). This suggests that concrete representations may be beneficial to students with MSD (Thompson, Bethune, Wood, & Pugalee, 2014) who often have difficulties with working memory, symbolic understanding, and abstract thinking.

Two studies (8%) used concrete representations in the context of the concrete–representational–abstract (CRA) approach. This approach uses concrete representations and systematically fades them in favor of symbolic representations to promote conceptual understanding of the mathematic knowledge or skill being taught (Strozier, Hinton, Flores, & Terry, 2015). While this strategy has been widely used for students at risk of failure in mathematics (Flores, 2009), or students with high-incidence disabilities (Harris, Miller, & Mercer, 1995), it appears that researchers are beginning to examine its utility with students with MSD. According to Strozier and colleagues (2015), the CRA instructional sequence includes instruction that begins at the concrete level using concrete manipulatives such as base 10 blocks. Then instruction is provided at the representational level, where semi-concrete methods are used to represent objects, such as drawings. Finally, instruction is provided on the abstract level, where the student will learn use symbols to solve mathematics problems.

Ten (42%) of the studies included in the review used real-world problems to teach mathematics skills from across all NCTM content standards to students across all grade bands (Browder, Jimenez, Spooner et al., 2012; Browder, Jimenez, & Trela, 2012; Creech-Galloway et al., 2013; Jimenez & Kemmery, 2013; Jimenez & Staples, 2015; Root, Saunders, Spooner, & Brosh, 2017; Spooner et al., 2012). Of the studies that utilized math stories, five (50%) included students with MSD in an elementary setting, three (30%) in a middle school setting, and two (20%) in a high school setting.

Math stories are similar to another well-known strategy used with typical and at-risk students as well as students with disabilities called anchored instruction. Anchored instruction is defined as "a way of situating, or anchoring, the learning of students in problems that seem authentic and meaningful to them, thus motivating them to use and enhance their understandings of math" (Bottge, Heinrichs, Chan, Mehta, & Watson, 2003, p. 6). Integrating mathematics with relevant contexts helps students with MSD engage with mathematical concepts in a meaningful way, while also promoting generalization of mathematics and literacy skills (Courtade, Lingo, Karp, & Whitney, 2013; Van de Walle, Karp, & Bay-Williams, 2015). Discussing anchored instruction, Bottge et al. (2003) state, "a motivating problem context is an important prerequisite to helping all students practice their skills, especially with students who have shown little or no motivation to do so in the past" (p. 20). For students with MSD, it is possible that this motivating context brings about the student engagement necessary to persevere in mathematics problem solving, while also reflecting the natural environment enough for the student to more easily generalize to their everyday environments (McDonnell & Hunt, 2014).

Another emerging strategy that was represented in the literature was modified schema-based instruction (MSBI). Two studies (8%) utilized MSBI to teach problem solving to students with MSD. Similar to the CRA instructional sequence, schema-based instruction is a strategy typically used with students with high-incidence disabilities or students at risk for math failure. It includes explicit instruction in problem structure, using visual representations, and heuristic training linked to problem types and procedural flexibility (Jitendra, Star, Dupuis, & Rodriguez, 2012). To account for the unique learning needs of students with MSD, researchers have begun to implement MSBI, which embeds systematic instruction including error correction and feedback, an interactive read aloud of a math story, concrete representations, providing a student task analysis to self-monitor, and scripted think-alouds to determine problem type (Spooner, Saunders, Root, & Brosh, 2017). While only two studies in this review used MSBI, it is notable that MSBI includes many of the other strategies identified (systematic instruction, math stories, and concrete representations) in conjunction with the self-monitoring task analysis and explicit instruction on problem types.

Eight (33%) studies included in this review utilized technology in some way to teach mathematics skills to students with MSD, although the types of technology and their role in instruction differed in each study. Three (13%) studies in this review evaluated technology-delivered anchored instruction and concrete representations (Creech-Galloway et al., 2013; Root, Browder, et al., 2017; Sheriff & Boon, 2014). Simulation was evaluated in two (8%) of the studies (Ayres, Langone, Boon, & Norman, 2006; Hansen & Morgan, 2008). Two (8%) studies looked at calculator use (Root, Saunders, et al., 2017; Yakubova & Bouck, 2014), one (4%) evaluated the use of a math game to teach number identification (Everhart, Alber-Morgan, & Park, 2011), one (4%) utilized single-switch voice output devices (Hudson, Zambone, & Brickhouse, 2016), and one (4%) measured generalization from a worksheet to an iDevice (Root, Saunders, et al., 2017).

Technology has shown to be effective in providing anchored instruction. In a study by Creech-Galloway and colleagues (2013), students were taught to solve problems using the Pythagorean theorem. As a part of the instructional package (simultaneous prompting and task analytic instruction), the researchers also utilized an iPad to present real-life scenarios where the Pythagorean theorem was needed, giving the students a motivating problem context to learn a high-level mathematics skill.

In addition to anchored instruction, technology can also provide access to concrete representations. In a study by Sheriff and Boon (2014), researchers used computer-based graphic organizers to teach middle school students with ID to solve word problems. The computer software utilized provided students with a template with the equation and boxes for each number. Students then used a calculator to find the solution. All participants showed marked increases in their ability to solve word problems, including the one participant who had an IQ that fit within this review's inclusion criteria (<60). In addition, in the Root, Browder, et al. (2017) study on using MSBI to teach elementary students with autism spectrum disorder (ASD) and moderate ID how to solve word problems, they found that two out of the three students showed quicker acquisition of the skill using the virtual compared with the concrete manipulatives. Furthermore, all three students showed preference for the virtual manipulatives in the maintenance stage of the study. From providing a means of using virtual manipulatives to active simulation of a real-world environment, technology shows to play many roles in providing effective mathematics instruction for students with MSD.

Generalization

Teaching for generalization is an important consideration for teaching academics to students with MSD (Spooner et al., 2012), who may have difficulty applying knowledge and skills to new settings and materials. Sixteen (67%) out of the 24 studies in this review planned to teach for generalization. Generalization across materials was evaluated in seven studies (29%). Generalization across settings was evaluated in nine studies (38%). Finally, generalization across multiple exemplars was evaluated in four (17%) studies. In addition, some studies showed that technology can increase generalization of skills to real-world settings. In the study by Ayres et al. (2006), researchers reported that the participants who were receiving typical classroom-based instruction on purchasing items were not demonstrating these same skills in community grocery stores. They added the use of a computer-based program (Project Shop CD-ROM; Langone, Clees, Rieber, & Matzko, 2003) to provide simulation instruction. The addition of the computer-based program into the students' classroom instruction was effective in supporting students' abilities to generalize skills learned in the classroom to real-world settings.

Discussion

This review sought to determine the extent to which mathematics content taught to students with MSD in single-case research studies conducted since the reauthorization of IDEA 2004 addressed the five NCTM content standards and to describe the practices that were used to teach mathematics to this group of students. Browder et al. (2008) found that roughly one-half of the studies included in their meta-analysis covered numbers and operations, and the other half covered measurement. This review found about three-quarters of the studies covered numbers and operations, with roughly a third of the studies addressing measurement, algebra, and geometry. Data analysis/probability had the lowest representation at 4% of the studies.

These results suggest that researchers have begun to expand the range of math content taught to students with MSD. However, it is also clear that much more research in this area is needed if practitioners are going to ensure that students have equal access to the core curriculum and successfully meet their unique learning needs. In addition, the passage of the Every Student Succeeds Act (ESSA) of 2015 suggests that the expectations for all students to participate and progress in the general education curriculum is likely to remain in place for the foreseeable future. Furthermore, the available evidence suggests that most states currently include all five NCTM content standards as a part of the general curriculum and many states include them in their alternate assessments (Domaleski, Thompson, & Dadey, 2016; Dynamic Learning Maps, 2017). Practitioners will face significant challenges in assisting students to meet these expectations without continued efforts to develop and validate strategies for teaching mathematics content beyond numbers and operations.

All of the studies included in the review employed instructional strategies that have been shown to be effective in teaching academic skills, including mathematics, to students with MSD (Browder et al., 2008; Hudson, Browder, & Wood, 2013; King, Lemons, & Davidson, 2016; Spooner et al., 2012). However, findings indicated that researchers are increasingly examining instructional approaches that have been found to be effective in teaching mathematics to students without disabilities including the use of the CRA instructional approach, schema-based instruction, anchored instruction, and the use of technology (Bottge et al., 2003; Jitendra et al., 2012; NCTM, 2000; What Works Clearinghouse, 2012; Yakubova et al., 2016). This is a promising finding because it shows that researchers are becoming more cognizant of the need to teach the conceptual processes that undergird the successful use of mathematics in day-to-day activities including problem solving, reasoning and proof, communicating mathematical ideas, making mathematical connections, and representing mathematical ideas (NCTM, 2000). This is especially relevant given the difficulties students with MSD have demonstrated with solving real-world problems (Kearns, Towles-Reeves, Kleinert, Kleinert, & Thomas, 2011). Perhaps taking a more holistic approach to mathematics instruction, teaching both concepts and operations with conceptual processes, will open the door for the development of new approaches to teaching mathematics that have immediate and tangible impact on students' participation in home, school, and community activities.

The findings suggest that technology may provide an important instructional platform to teach mathematical knowledge and skills. Over a third of the studies included in the review incorporated technology into the instructional packages to teach mathematics to students with students in a variety of ways. Clearly, the power and flexibility of today's digital devices allow for the development of instructional formats that include evidenced-based practices (e.g., response prompting and fading, error correction), concrete representations, schema-based learning, and anchored instruction. Unfortunately, the field has little information about the instructional design principles that should drive the development of these instructional platforms for students with MSD (Ayres & Langone, 2005; Butcher & Jameson, 2016; Wissick, Gardner, & Langone, 1999).

Another positive finding was that over 60% of the studies planned to teach and assessed generalization of targeted mathematics skills. These results are consistent with previous reviews that have examined the issue of generalization in studies teaching academic skills (Spooner et al., 2012). Ensuring that students can apply newly learned content across people, settings, materials, and multiple exemplars ensures that the content and skills will be available to the student outside of the exact circumstances in which they learned the skill. However, skills should also be assessed in a way that ensures that the skill taught can be directly applicable within the context of daily living (i.e., budgeting, determining the number of items needed to complete a task, interpreting a basic graph in a newspaper, etc.). If the skills students learn are not directly applicable in the context of daily living, then it should be determined if they are prerequisite skills. If the skills are prerequisite skills, consideration should be made as to how they lead to a direct application and how the progression to the most meaningful generalization will occur. Future research on teaching mathematics content to students with MSD must begin to address how to promote the application of these skills beyond academic tasks and school settings (Ayres, Lowrey, Douglas, & Sievers, 2011; McDonnell & Hunt, 2014; Spooner et al., 2017).

The mandate in IDEA (2004) for all students with disabilities to participate and progress in the general education curriculum presented significant challenges to teachers, schools, and school districts. Research reviews on teaching math at the time (Browder et al., 2008) suggested that while the field was not completely unprepared to meet these challenges, much more work was needed to be done to meet those two goals. This literature review analyzed single-case research studies from 2005 through March 2017. In conclusion, while much more research is needed, the field has made progress in developing instructional approaches and strategies to teach a wider range of mathematics content to students with MSD and has begun to validate new strategies for teaching the underlying conceptual processes that are necessary for students to successfully apply math knowledge in their daily lives.

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