Getting Past “I Hate Math!”

Sarah A. Nagro  
*George Mason University*

Margaret P. Weiss  
*George Mason University*

Jaime True Daley  
*Johns Hopkins University*

THE RUB: MATHEMATICS AND STUDENTS WITH DISABILITIES

Wait, what? A student with a disability who doesn’t like math? Say it isn’t so! But yes, we all know this far too well. We also know that responding to “Why do I ever have to know how to write a geometry proof” with “Because it’ll be on the test” simply isn’t a good strategy. What can we do, and why has there been such a push for problem-based mathematics?

Improving student outcomes through effective academic instruction has always been key. The passage of the No Child Left Behind Act (NCLB) of 2001 provided an even bigger push to do so (NCLB, 2002). The consensus was that to better prepare students for postsecondary success, greater
focus needs to be on improving academic outcomes for students across content areas and particularly in mathematics (NCLB, 2002). The Common Core State Standards Initiative (CCSSI, 2010) was enacted to do just that by introducing more rigorous national mathematics standards that promote critical thinking and problem solving. Even though not all states embrace the Common Core State Standards (CCSS), all national mathematics standards indicate that students must be able to reason abstractly and quantitatively to be career and college ready, yet these skills are challenging for even the best students. As a result, mathematics curriculum persists as one of the most difficult aspects of school for students with disabilities (Miller & Hudson, 2007).

Despite higher standards for student learning and improved instructional approaches, students with disabilities continue to struggle in math. Nationwide, students with disabilities are performing far below the national averages. That might not surprise you—naturally, students with special needs would struggle more than students without disabilities. But will this surprise you? Only 18% of fourth graders and 8% of eighth graders performed at a proficient or advanced level on the 2013 Nation’s Report Card (National Center for Education Statistics, 2013). Ouch! Compared to the 42% of all fourth graders and 35% of all eighth graders without disabilities nationwide who are performing at or above proficient in mathematics, the differences are striking. Put simply, students with disabilities are failing math at much higher rates than their nondisabled peers. (Though, obviously, we need to do better in teaching math across the board.)

The reasons students with disabilities struggle in math are well documented. Many students with disabilities lack number sense or the ability to interact with numbers in a fluid and flexible manner (Gersten & Chard, 1999). Number sense is the ability to seamlessly translate abstract mathematical expressions into real-world concepts. Students with disabilities who lack number sense and experience additional cognitive difficulties often experience deficits in organizational skills, higher order thinking, working memory, learning and retaining operational skills, connecting conceptual knowledge with tangible representations, and academic risk taking (Montague, Krawec, Enders, & Dietz, 2014). Additionally, students with more pervasive disabilities tend to struggle with fine motor skills due to the “inability to plan, organize, and coordinate movement” (Gibbs, Appleton, & Appleton, 2007, p. 534). These students tend to struggle with spatial representation of numerical values, misinterpret visually represented material, and face deficits in writing and reading comprehension when accessing the general curriculum (Geary, 2004). Just imagine struggling with math concepts only to be introduced to word problems and learn that now you get to struggle with math, reading, and writing . . . all at once!
Many of the challenges students with disabilities face when trying to learn mathematics align to shifts in the CCSS focus. For example, key mathematical practices that span across all grades under the CCSS require students to persevere in problem solving, reason abstractly, construct viable arguments, communicate with precision, and identify structural patterns and relationships. Do any of those sound like they might be challenging for a student with a disability? We think so, too. In fact, difficulties in information processing, including working memory and executive functioning problems, as well as making meaning from text and generalizing strategies across contexts will have an impact on a student’s success in mathematical practices. Steps can, and should, be taken to mitigate the many challenges faced by students with disabilities in mathematics education. That’s where this chapter comes in.

**WHAT RESEARCH SAYS REALLY WORKS IN MATHEMATICS FOR STUDENTS WITH DISABILITIES**

Researchers have identified several research- and evidence-based practices that promote positive student learning dispositions, flexible concept understanding, reflective decision making, greater confidence in mathematics abilities, and improved academic performance for students with disabilities (Gurganus, 2007). With all this information, it should be a piece of cake to teach math effectively to students with disabilities, right? Not quite, but at least there are confirmed strategies that help. The research- and evidence-based practices covered in this chapter can be summarized into three categories: graduated instructional sequence, commonly referred to as the concrete-representational-abstract (CRA) sequence; combined cognitive and metacognitive strategies instruction; and schema-based instruction (SBI). This chapter briefly reviews the essential components and gives specific examples of all three.

**Graduated Instructional Sequence**

Graduated instructional sequence, or CRA, is a three-stage process used to develop conceptual knowledge in mathematics (Mancl, Miller, & Kennedy, 2012). Students learn the conceptual underpinnings of topics, such as factoring equations in algebra, by progressing through stages that include concrete demonstrations or introducing physical manipulatives to...
depictions represent conceptual properties (e.g., holding three apples), followed by representational or pictorial depictions (e.g., three tally marks or three pictures of apples), and concluding with abstract depictions or problems presented in symbolic notation or written form (e.g., 3 or three; Mancl et al., 2012). The CRA stages are taught using the principles of explicit instruction including modeling and identification of critical components, as well as guided and independent practice with examples and nonexamples (Archer & Hughes, 2011).

Mathematics CCSS (CCSSI, 2010) place an emphasis on successive concepts, such as algebra, across grade levels. Though many educators seem to think that manipulatives (the C in the CRA teaching sequence) are for primary or elementary grades only, their use has been advocated for and proven effective in higher level mathematics as well (e.g., Miller & Hudson, 2007). For example, using algebra tiles in the concrete phase of the CRA teaching sequence, students with disabilities can “see” all basic algebraic operations (Maccini, Mulcahy, & Wilson, 2007). This often helps students without disabilities as well. Think about how students are typically shown an abstract example on the board, such as $2x + 3 = 9$. Students are then instructed to subtract 3 from both sides of the equal sign, even if they might not grasp why. Setting up and solving the equation with algebra tiles helps students understand the underlying concept behind adding opposites (different colors of the same blocks) to equal zero. Moving students sequentially through the CRA teaching sequence during algebra instruction, and also during the introduction of any new math concept, can help link concrete concepts to abstract mathematical expressions for students who struggle to do so without such structure. So bring on the manipulatives!

**Combined Cognitive and Metacognitive Strategies Instruction**

Cognitive strategy instruction includes teaching students reasoning methods to enhance problem-solving skills, since problem solving is both an area of focus in mathematics (CCSSI, 2010) and an area of weakness for students with disabilities (Montague et al., 2014). Montague and Dietz (2009) reviewed the evidence base of cognitive strategy instruction including a 7-step process for attacking and solving word problems. The authors found cognitive strategy instruction showed promise for improving the problem-solving abilities of students with disabilities, particularly students with learning disabilities. The 7-step process includes: reading the problem to clear up uncertainty, putting the word problem in their own words, drawing or visually representing the problem, creating a plan to solve the problem, predicting the answer, computing the answer, and then checking the answer. Pretty logical, right?
Despite the success of the cognitive strategy instruction, many students with disabilities require additional help understanding how to approach problem solving (Montague, Warger, & Morgan, 2000). Combining metacognitive strategies instruction with cognitive strategies promotes a holistic approach to effective and efficient problem solving (Jitendra, DiPipi, & Perron-Jones, 2002). One metacognitive strategy is a 3-step process called Solve it! where students coach themselves through each of the seven problem-solving steps. Students follow a sequence of say, ask, check to say the purpose of the step, ask what is required in that step, and check to assure the step is completed (Montague et al., 2000). Combining cognitive and metacognitive strategies in this way can improve independence for students with disabilities who are learning math.

**Schema-Based Instruction**

Even after implementing combined cognitive and metacognitive strategy instruction, students with disabilities may still struggle to persist in problem solving (CCSSI, 2010). We know—you’re shocked. It’s true though; disabilities that impact math just do not go away that easily. Reasons for this enduring struggle include the inability to learn and retain operational skills, gaps in higher order thinking, and failure to apply a systematic strategy (Lerner, 2003). Traditionally, students are taught to recall specific operations based on key words within problems. Focusing on scanning for key words and then recalling rules or procedures rather than emphasizing big picture comprehension of mathematical concepts may actually be perpetuating the challenges students face in mathematics (Dingfelder, 2007). This is just so far away from what we’ve traditionally done with students with disabilities and math so it can be a difficult shift for many educators.

Schema-based instruction can help address such challenges by teaching students to categorize word problems graphically in a way that guides meaning and structure recognition (Jitendra, Griffin, Deatline-Buchman, & Szesniak, 2007). For example, students can group word problems into change problems (e.g., requiring addition or subtraction), group problems (e.g., requiring the combination of groups or sets), or compare problems (e.g., describing relationships between numbers) (Dingfelder, 2007; Jitendra, Hoff, & Beck, 1999). Approaching word problem instruction in this manner can build students’ schema about ways most problems can be solved (Montague & Jitendra, 2006). Essentially, you are providing students with a visual graphic organizer to help them understand their math.

As we’ve stated, students with disabilities frequently struggle with math, and yet math is a major area of emphasis in all schools. Using the CRA (concrete-representational-abstract) progression, adding in metacognitive and cognitive strategies to make students aware of their processes, and providing schema to help them see how they are solving their problems, are all evidence-based approaches for helping students learn math.
Here are a few of our major dos and don’ts when it comes to teaching students with disabilities mathematics.

**SABOTAGING MATH INSTRUCTION AND STUDENT LEARNING**

Teachers and Administrators:

- STOP using drill and fill worksheets that were premade for general consumption. This style of instruction reinforces passive learning for students with disabilities who do not make connections between procedural probes and mathematical concepts. Plus, they’re boring!
- STOP teaching math tricks that do not link the process for solving problems to the mathematical concepts these problems are used to teach. We all love magic, but if the students don’t understand why the trick works, what’s the point?
- STOP handing out calculators as a standalone support. Students with disabilities already struggle with number sense, and using calculators in this way requires additional procedural awareness, a common area of relative weakness. They may be fine as an accommodation, but not as your answer for how to teach math.
- STOP jumping from instruction to independent practice without sufficient guided practice. Many students who lack number sense cannot generalize concepts across probes without supports. Be ready to differentiate. Some of your students may be ready for independent practice before others; prepare for that.
- STOP targeting one type of learning mode (visual, auditory, kinesthetic) during mathematics lessons. Though the research on learning styles hasn’t been validated, we can all agree that students don’t learn in one way. Instead, use multiple means of representing the material to account for students’ relative strengths (e.g., listening comprehension) and weaknesses (e.g., processing delays). This also goes along nicely with the emphasis on Universal Design for Learning (see www.cast.org).
- STOP giving homework that includes new concepts. Homework is meant to review and reinforce. It is not meant to help a teacher move ahead in the curriculum more quickly. For students with special needs, homework may already be taking more time than nondisabled peers.
in completing; to add in information that has not been presented almost guarantees that the student will not do it or will do it wrong. You may even want to watch the film Race to Nowhere (www.racetonowhere.com) to see if it impacts your overall view of homework for all students, not just those who are special learners.

SUCCESSFULLY TEACHING MATH TO ALL STUDENTS, INCLUDING EXCEPTIONAL LEARNERS

Teachers and Administrators, DO this:

✔ USE the Pyramid Planning approach when planning for whole group math instruction. Most of the time, math teachers are instructing the entire class, including students with special needs, and it can be difficult to differentiate for so many students. The Planning Pyramid for mathematics instruction helps decide what all, some, and just a few students will learn as well as the resources needed to achieve such learning objectives.

✔ HAVE high expectations for your students’ learning—don’t water it down, break it down. This can be done by identifying the big picture, the ultimate learning objective, the “My students will be better off if they just learn this one thing today” concept, and then break that concept down by targeting individual components.

✔ USE the CRA instructional sequence when introducing new topics. This gradual release framework will help students make their own connections during learning experiences by blending concrete demonstrations and abstract depictions in a structured way. First model with concrete objects and have students repeat. Then model several examples using pictorial representations and have students repeat the practice with a partner while you prompt them with supportive questioning. Provide an abstract representation of a concept only after students master them with scaffolds.

✔ VARY the “calculation devices” used as accommodations. Go beyond the calculator to support students by providing number
charts, fraction charts, and place value boards. Again, these suggestions are to support students in understanding math, not merely memorizing procedures. Provide visual guides such as t-charts for function tables, time lines for elapsed time, and area models for partial product multiplication and partial quotient division. Use printed examples in page protector sleeves with dry erase markers to provide resources for students to reuse with homework and assignments. Consider creating a resource binder with customized tools. We’ve provided several examples for you at the end of this chapter.

✔ **ASK students to explain their reasoning.** Plugging numbers into a formula for 30 problems straight is not actually showing comprehension of math concepts. Students who can explain their thinking and process for solving a math problem will have an easier time generalizing these concepts across contexts, especially since math in everyday life is not predictable like math textbooks. Build on student strengths by asking, or letting them choose, to explain in writing, orally, on video, or in pictures to build confidence with expressing themselves.

✔ **PROMOTE perseverance in problem solving by providing student-centered supports.** These student-centered supports might include anchor charts, manipulatives, hint cards, self-correcting materials, graphic organizers, and self-monitoring checklists. For ideas of how to make activities student centered, check out what these distinguished math teachers are doing through their blogs listed in the call out box or visit Math Landing at http://www.mathlanding.org/content/hint-cards for teacher resources, tools, and videos on effective strategies such as using hint cards in your own math classroom.

✔ **USE schema-based instruction to help students solve word problems.** Teach students that every math problem asks them to find an unknown, but most of the information is given. Provide students with diagrams to show the whole to part relationship, such as a whole rectangle with two smaller rectangles drawn under it (see figures at the end of the chapter). The purpose of schema-based instruction is to help students look at math problems and identify patterns rather than only focusing on solving each problem in isolation. One suggestion is to teach students specific patterns of problems such as change or grouping without any missing
information first to help them master the learning technique before having to actually use it.

✔ **USE precision in math language.** Focus on increasing students’ comfort in using math language rather than emphasizing the memorization of math rules to help students make connections and generalize abstract math concepts across contexts and across the curriculum. For example, begin by reviewing a stack of 5 to 10 related vocabulary terms with pictorial representations of the terms. Generate a sentence that defines and links the terms to each other. Then expect students to use the terms throughout the lesson. Refer back to vocabulary cards as needed. Challenge yourself and students to use these same terms during future math lessons or even during cross-curricular discussions in science or reading.

✔ **ALLOW for sufficient guided practice that includes verification of accuracy and strategy use.** Start with the “Rule of 9” for how frequently to model concepts (3 times), guide small groups or partners (3 times), and require independent practice (3 times). Students with disabilities may require additional guided practice with models, manipulatives, or self-correcting materials before independent practice such as the customizable self-correcting checklists available at http://www.interventioncentral.org/academic-interventions/math/self-monitoring-customized-math-self-correction-checklists. To help students verify accuracy and strategy use, consider introducing self-monitoring student checklists such as the ones available through Positive Behavior Interventions and Supports (PBIS) World at http://www.pbiswa.com/tier-2/self-monitoring.

✔ **USE cognitive strategies.** Try the 7-step problem solving strategy and metacognitive strategies, such as the 3-step process called **Solve it!**, to coach students through thinking about and attacking problem solving. Cognitive and metacognitive strategies are likely new concepts for students who are not always expected to think about their thinking. This can be overwhelming to introduce all at once, especially with all the other new strategies introduced in this chapter. Introduce one strategy at a time, and practice the selected strategy until it is mastered before introducing another. First, use the strategy as a whole class. Model the steps of the strategy using think-alouds and anchor charts. Then gradually shift the responsibility to the students by asking them to complete one, then two, then three (and so on) steps of the strategy independently before checking back in with a teacher. Once you know they are on the right track, you can provide positive reinforcement and prompt students to continue
their learning process (known as the *catch and release technique*). It may take a few lessons to successfully introduce a new cognitive or metacognitive strategy, but once students have the hang of it, you will increase instructional time by reducing confusion and necessary redirection that interrupts learning.

✔ **Provides** students with choices when approaching problem solving. Hard to reach students such as the nonstarters, students who avoid tasks, or those easily frustrated will benefit from having choices when approaching learning. Choice making can increase student motivation and independence. Embed choices into math lessons whenever possible. Simple choice making templates include a tic-tac-toe board where students choose three math problems to complete to successfully win the tic-tac-toe game. Another more complex choice making strategy that can help with differentiating instruction is a learning menu. Students can choose an appetizer (a planning strategy or graphic organizer), an entrée (the problem to solve), and a dessert (an extension activity that links the problem to larger concepts or daily life) from the learning menu to achieve a learning objective.

✔ **Asks** open-ended mathematical questions. Asking open-ended questions does two things for students. First, it helps them understand that there isn’t a definite “this way is the right way” to answer math questions. Second, it allows you the opportunity to say, “Tell me more” so that you can check the metacognitive strategies that students are using to solve problems.

✔ **Asks** students what they “notice” and what they “wonder” before teaching a new concept to assess their current levels of understanding. This allows you to assess their use of vocabulary (precision in language) as well as to see if they can apply previous concepts to new learning. One of the most important components of math is using what you already know to solve problems that don’t look exactly the same. If students are encouraged to hypothesize, they take ownership of what they know and are then asking the question of what comes next on their own.

✔ **Draws** connections between students’ lives and mathematical concepts to promote desired student learning dispositions such as authentic engagement. For example, when creating practice or example problems, use students’ names and situations...
they may find around school or at home. Instead of solving endless equations like $2x + 3 = 12$, put students into the problems. “Joe is at the basketball game. His friends ask him to buy some popcorn for them. He has $5 and each bag of popcorn costs $0.75. But he really wants some Skittles. They are $0.50. If he buys the Skittles for himself, how many friends can he buy popcorn for? What should Joe figure out first? Why?” This promotes student engagement and helps students see how they use math every day.

✔ **POSE real-world problems to students that require application of mathematical concepts.** Again, it is so important to show students that math is something we need and use in the real world, not just numbers repeated over and over on a page. Rather than focusing strictly on memorizing math rules, try posing real-life problems that happen to require target math concepts to solve the problem. For example, you can use Google Earth in your math class to “visit” actual crop circles in Wiltshire, England, a fractal coastline in Ireland, or the surface of the Earth and pose questions about complex area, circumference, estimating, distance, exchange rates, line graphs, and so much more.

✔ **PROVIDE multiple opportunities to practice math concepts and procedures with feedback.** While we continue to stress digging deeper into math concepts, which means more time spent on each math problem, it is still critical to expose students, particularly students with disabilities, to repetition. A major league baseball pitcher throws hundreds of practice pitches to develop muscle memory, and similarly, we want our students to develop math muscle memory. How can you both dig deep into critical math thinking and help students develop math muscle memory through repetition? Find a balance between breadth and depth. Focus on breadth when introducing new concepts and depth when reinforcing previously introduced concepts while always giving students opportunities to respond so that you can “catch” misconceptions and “release” students back to student-centered learning (yes, the catch and release technique again).

✔ **PROVIDE immediate and specific feedback to students during guided practice.** Immediate feedback helps ensure high rates of success and reduces the likelihood of practicing errors. As a colleague likes to say, “Practice makes permanent.” You don’t want that practice to be incorrect, and then you have to reteach a concept or strategy. As a student is learning new concepts or strategies, make sure you are watching, checking in, and providing immediate
and specific feedback in terms the students understand. Then ask them to do it again until they become independent.

✔ **FACILITATE peer-to-peer interactions as well as model appropriate peer feedback routines.** In other words, teach students to work together in math. Put them in pairs or small groups, and give them scripts for giving feedback, correcting their peers, and talking about math. First, have them practice these interactions with material they already know. Provide feedback about their collaboration and dialogue. Then have them practice again!

✔ **MONITOR student comprehension throughout the lesson with frequent check-ins.** We’ve all seen it—as a teacher gives instruction, she asks three questions. The same student answers all three questions. Everyone else seems to be writing things down and following along. “Great! They all get it,” she thinks. Wrong. She only knows that the student who answers gets it. Have students answer your questions on whiteboards and raise them up so you can see. Have students use laminated cards with numbers to raise up answers in response to your questions. Teachers must check in with students with disabilities, in particular, throughout instruction to see how they are progressing.

✔ **TRY new techniques that are supported by quality research.** Visit reliable peer-reviewed journals and organization websites to learn about new instructional strategies and techniques. Currently, Whole Brain Math teaching strategies, which combine direct instruction, peer-to-peer interactions, high opportunities to respond, and immediate feedback, are being researched in classrooms across the United States, Canada, Europe, and elsewhere. To read about the research behind this systematic approach to math instruction and to watch videos of actual teachers employing Whole Brain Math, visit [http://wholebrainteaching.com](http://wholebrainteaching.com).

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**Plugged In**

To learn more about **Classwide Peer Tutoring** and **Peer Assisted Learning** in math, visit [http://www.council-for-learning-disabilities.org/peer-tutoring-flexible-peer-mediated-strategy-that-involves-students-serving-as-academic-tutors](http://www.council-for-learning-disabilities.org/peer-tutoring-flexible-peer-mediated-strategy-that-involves-students-serving-as-academic-tutors) and [http://www.readingrockets.org/article/using-peer-tutoring-facilitate-access](http://www.readingrockets.org/article/using-peer-tutoring-facilitate-access).

Visit [http://trackstudentlearning.weebly.com](http://trackstudentlearning.weebly.com) to download, customize, and print formative assessment templates that align with whole group responding techniques to track student participation and comprehension during math.
### CALCULATION DEVICE OPTIONS ACROSS MATH CONCEPTS

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<th>Key Mathematical Concept</th>
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Change Diagram

Beginning

Change

Ending

Group Diagram

Parts (Small Groups)

Whole (Large Group)

Compare Diagram

Difference

Compared

Referent

REFERENCES


**ADDITIONAL RECOMMENDED READING**


**TOP WEBSITES TO SUPPORT MAKING MATH ACCESSIBLE**

- http://dwwlibrary.wested.org
- http://www.nctm.org
- https://www.frontrowed.com
- https://www.tenmarks.com
- http://www.intensiveintervention.org/intervention-type/mathematics
- http://www.ldonline.org/article/c665
APPS WE LOVE

- Math Maze!
- Monster Math Multiplayer
- Zap Zap Fractions
- Math Shake
- Mental Arithmetic Math Workout