INTERVENTION CENTRAL

RTI Toolkit: A Practical Guide for Schools

Best Practices in Elementary Math Interventions (K-6)

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Contents

Workshop materials at: http://www.interventioncentral.org/wi_ed_math_elementary

How To: Deliver Direct Instruction in General-Education Classrooms

When teachers must present challenging academic material to struggling learners, they can make that material more accessible and promote faster learning by building assistance directly into instruction. Researchers use several terms to refer to this increased level of student instructional support: direct instruction, explicit instruction, or supported instruction (Rosenshine, 2008).

The checklist below summarizes the essential elements of a direct-instruction approach. When preparing lesson plans, instructors can use this resource as a 'pre-flight' checklist to make sure that their lessons reach the widest range of diverse learners.

1. Increase Access to Instruction	
Instructional Element	Notes
☐ Instructional Match. Lesson content is appropriately matched to students' abilities (Burns, VanDerHeyden, & Boice, 2008).	
☐ Content Review at Lesson Start. The lesson opens with a brief review of concepts or material that have previously been presented. (Burns, VanDerHeyden, & Boice, 2008, Rosenshine, 2008).	
☐ Preview of Lesson Goal(s). At the start of instruction, the goals of the current day's lesson are shared (Rosenshine, 2008).	
☐ Chunking of New Material. The teacher breaks new material into small, manageable increments, 'chunks', or steps (Rosenshine, 2008).	

2. Provide 'Scaffolding' Support	
Instructional Element	Notes
☐ Detailed Explanations & Instructions. Throughout the lesson, the teacher provides adequate explanations and detailed instructions for all concepts and materials being taught (Burns, VanDerHeyden, & Boice, 2008).	
☐ Think-Alouds/Talk-Alouds. When presenting cognitive strategies that cannot be observed directly, the teacher describes those strategies for students. Verbal explanations include 'talk-alouds' (e.g., the teacher describes and explains each step of a cognitive strategy) and 'think-alouds' (e.g., the teacher applies a cognitive strategy to a particular problem or task and verbalizes the steps in applying the strategy) (Burns, VanDerHeyden, & Boice, 2008, Rosenshine, 2008).	
☐ Work Models. The teacher makes exemplars of academic work (e.g., essays, completed math word problems) available to students for use as models (Rosenshine, 2008).	
☐ Active Engagement. The teacher ensures that the lesson engages the student in 'active accurate responding' (Skinner, Pappas & Davis, 2005) often enough to capture student attention and to optimize learning.	
☐ Collaborative Assignments. Students have frequent opportunities to work collaboratively--in pairs or groups. (Baker, Gersten, & Lee, 2002; Gettinger & Seibert, 2002).	
☐ Checks for Understanding. The instructor regularly checks for student	

understanding by posing frequent questions to the group (Rosenshine, 2008).	
☐ **Group Responding.** The teacher ensures full class participation and boosts levels of student attention by having all students respond in various ways (e.g., choral responding, response cards, white boards) to instructor questions (Rosenshine, 2008).	
☐ **High Rate of Student Success.** The teacher verifies that students are experiencing at least 80% success in the lesson content to shape their learning in the desired direction and to maintain student motivation and engagement (Gettinger & Seibert, 2002).	
☐ **Brisk Rate of Instruction.** The lesson moves at a brisk rate--sufficient to hold student attention (Carnine,1976; Gettinger & Seibert, 2002).	
☐ **Fix-Up Strategies.** Students are taught fix-up strategies (Rosenshine, 2008) for use during independent work (e.g., for defining unknown words in reading assignments, for solving challenging math word problems).	

3. Give Timely Performance Feedback

Instructional Element	Notes
☐ **Regular Feedback.** The teacher provides timely and regular performance feedback and corrections throughout the lesson as needed to guide student learning (Burns, VanDerHeyden, & Boice).	
☐ **Step-by-Step Checklists.** For multi-step cognitive strategies, the teacher creates checklists for students to use to self-monitor performance (Rosenshine, 2008).	

4. Provide Opportunities for Review & Practice

Instructional Element	Notes
☐ **Spacing of Practice Throughout Lesson.** The lesson includes practice activities spaced throughout the lesson. (e.g., through teacher demonstration; then group practice with teacher supervision and feedback; then independent, individual student practice) (Burns, VanDerHeyden, & Boice).	
☐ **Guided Practice.** When teaching challenging material, the teacher provides immediate corrective feedback to each student response. When the instructor anticipates the possibility of an incorrect response, that teacher forestalls student error through use of cues, prompts, or hints. The teacher also tracks student responding and ensures sufficient success during supervised lessons before having students practice the new skills or knowledge independently (Burns, VanDerHeyden, & Boice, 2008).	
☐ **Support for Independent Practice.** The teacher ensures that students have adequate support (e.g., clear and explicit instructions; teacher monitoring) to be successful during independent seatwork practice activities (Rosenshine, 2008).	
☐ **Distributed Practice.** The teacher reviews previously taught content one or more times over a period of several weeks or months (Pashler et al., 2007; Rosenshine & Stevens, 1995).	

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How Do We Reach Low-Performing Math Students?: Instructional Recommendations *Important elements of math instruction for low-performing students* (Baker, Gersten, & Lee, 2002; p. 51):	*IDEAS FOR IMPLEMENTATION*
"Providing teachers and students with data on student performance"	
"Using peers as tutors or instructional guides"	
"Providing clear, specific feedback to parents on their children's mathematics success"	
"Using principles of explicit instruction in teaching math concepts and procedures."	

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Baker, S., Gersten, R., & Lee, D. (2002).A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal, 103*(1), 51-73.

How To: Match the Student to the Right Academic Intervention with the Instructional Hierarchy

Teachers recognize that learning is a continual process of growth and improvement. The student who grapples with the rudiments of a skill such as reading appears very different from the more advanced student who is a proficient and self-motivated reader. Intuitively, then, educators understand that students advance through predictable stages of learning as they move from novice to expert in a particular skill.

The Common Core Standards, too, acknowledge advancing levels of learning, as can be seen in their wording. For example, a 6th-grade Common Core Standard for Mathematics on the Number System (CCSM.6.NS.2) states that the student will "fluently divide multi-digit numbers using the standard algorithm." (National Governors Association Center for Best Practices et al., 2010; p. 42). This standard assumes that the successful student is both (1) accurate and (2) proficient (i.e., fluent) in multi-digit division--and implies as well that the student (3) will retain the skill over time, (4) will have the endurance to complete grade-appropriate tasks that include the skill, and (5) can flexibly apply or generalize the skill to those situations and settings in which multi-digit division will be useful.

The Instructional Hierarchy-IH (Haring et al., 1978) is a helpful framework to analyze stages of student learning. The Instructional Hierarchy breaks the learning process into several levels, shifting from skill acquisition through skill mastery toward full integration of the skill into the student's academic repertoire. As presented here, the Instructional Hierarchy consists of 5 levels (Haring et al., 1978; Martens & Witt, 2004): Acquisition, fluency, retention, endurance, and generalization. Although initially formulated several decades ago, the Instructional Hierarchy is widely used as a model of learning in contemporary research into effective instruction and academic intervention (e.g., Ardoin & Daly, 2007).

By linking a particular student's target skill to the corresponding IH learning stage, the teacher can gain insight into what instructional supports and strategies will help that student to attain academic success. This linkage of learner to learning stage increases both teacher confidence and the probability for a positive student outcome. The table below (adapted from Haring et al., 1978 and Martens & Witt, 2004) gives instructors a brief description of each learning stage in the Instructional Hierarchy, along with suggested instructional strategies and a sample intervention idea:

1. Acquisition
Goal. At the beginning of the acquisition stage, the student has just begun to acquire the target skill. The objective is for the student to learn how to complete the skill accurately and repeatedly--without requiring the help of another. Instructional Strategies. When just beginning a new skill, the student learns effectively through learning trials, in which the teacher: (1) *models* how to perform the skill, (2) *prompts* the student to perform the skill; and (3) *provides immediate performance feedback* to shape the student's learning in the desired direction. The teacher can maintain student motivation by providing frequent 'labeled praise' (that is, praise that specifically describes the student's positive academic behaviors and effort) and encouragement. As the student becomes accurate and more independent in the skill, the teacher can gradually fade prompting support. Sample Intervention Idea. *Cover-copy-compare* is a student-delivered intervention that promotes acquisition of math-facts or spelling words (Skinner, McLaughlin, & Logan, 1997). The student is given a blank index card and a worksheet with spelling words or math-facts (with answers) appearing in the left column. One at a time, the student studies each original model (spelling word or math fact), covers the model with index card, from memory copies the model (spelling word or math-fact equation and answer)

into the right column of the worksheet, then uncovers the model to confirm that the student work is correct. NOTE: This intervention is most appropriate for use as the student has acquired some accuracy and independence in the target skill.

2. Fluency

Goal. The student who advances into the fluency stage can complete the target skill with accuracy but works relatively slowly. The objective is for the student to maintain accuracy while increasing speed of responding (fluency).

Instructional Strategies. The student who has acquired the skill but must become more proficient benefits from (1) brief, frequent opportunities to practice the skill coupled with (2) instructional feedback about increasing speed of performance (Martens & Witt, 2004). To facilitate fluency-building, the teacher structures group learning activities to give the student plenty of opportunities for active (observable) responding. The student is also given multiple opportunities for drill (direct repetition of the target skill) and practice (combining the target skill with other skills to solve problems or accomplish tasks). The student receives feedback on the fluency and accuracy of the academic performance, as well as praise and encouragement tied to increased fluency.

Sample Intervention Idea. An example of a group strategy to promote fluency in math-facts is *explicit time drill* (Rhymer et al., 2002). The teacher hands out a math-fact worksheet. Students are told that they will have 3 minutes to work on problems on the sheet. The teacher starts the stop watch and tells the students to start work. At the end of the first minute in the 3-minute span, the teacher 'calls time', stops the stopwatch, and tells the students to underline the last number written and to put their pencils in the air. Then students are told to resume work and the teacher restarts the stopwatch. This process is repeated at the end of minutes 2 and 3. At the conclusion of the 3 minutes, the teacher collects the student worksheets.

3. Retention

Goal. At the start of the retention stage, the student is reasonably fluent but is at risk of losing proficiency in the target skill through lapses in use. At this point, the objective is to 'overlearn' the skill to insure its retention even after long periods of disuse.

Instructional Strategies. Frequent opportunities for practice can be an effective method to entrench a skill and help the student to retain it over time (Martens & Witt, 2004). The teacher can schedule numerous practice episodes within a short time ('massed review') to promote initial fluency and then reinforce longer-term retention of the skill by scheduling additional periodic review ('distributed review') across longer spans of several weeks or even months (Pashler et al., 2007).

Sample Intervention Idea. An illustration of an intervention to promote retention is *repeated reading* (Lo, Cooke, & Starling, 2011). This intervention targets reading fluency: The student is given a passage and first 'rehearses' that passage by following along silently as the tutor reads it aloud. Then the student reads the same passage aloud several times in a row, with the tutor giving performance feedback after each re-reading. If a teacher uses a fluency-building strategy such as repeated reading but sets an ambitious outcome goal that is *above* the minimum benchmark for success, the resulting 'overlearning' can support long-term retention of the skill. For example, a 4th-grade teacher uses repeated reading with a student during a mid-year intervention and tracks the student's reading fluency using timed 1-minute curriculum-based measurement oral reading fluency passages. Benchmark norms (Hasbrouck & Tindal, 2005) suggest that the student will cross over into the 'low-risk' range for reading fluency if he can read at least 87 words per minute according to the mid-year benchmark norms for grade 4. The teacher decides instead to overshoot, setting the outcome goal to a higher 95 words per minute ('overlearning') to give the student an additional margin of reading fluency to promote long-term skill retention.

4. Endurance

Goal. At the onset of the endurance stage, the student has become fluent in the target skill but will engage in it only reluctantly or for brief periods. The goal is to have the student persist in the skill for the longer intervals of time required in the classroom setting or expected for the student's age group. (Martens & Witt, 2004)

Instructional Strategies. Several instructional ideas can promote increased student endurance. In structuring lessons or independent work, for example, the teacher can gradually lengthen the period of time that the student spends in skills practice or use. The student can also be enlisted to self-monitor active engagement in skill-building activities--setting daily, increasingly ambitious work goals and then tracking whether he or she successfully reaches those goals. NOTE: If a student appears to lack 'endurance', the teacher should also verify that the fundamentals of good instruction are in place: for example, that the student can do the assigned work (instructional match), adequately understands directions, is receiving timely performance feedback, etc.

Sample Intervention Idea. An idea to increase student endurance provides breaks between gradually lengthening work intervals (*'fixed-time escape'*: adapted from Waller & Higbee, 2010). This strategy can be used with groups or individual students. The teacher first selects a target activity for endurance-building (e.g., independent reading). The teacher then sets the length of work periods by estimating the typical length of time that the student or group will currently engage in the activity (e.g., 5 minutes) before becoming off-task or disruptive. The teacher also decides on a length for brief 'escape' breaks (e.g., 2 minutes)--times when students can stop work and instead take part in preferred activities.

At the start of the intervention, the teacher directs the student or group to begin the target work activity. At the end of the work interval (e.g., 5 minutes), the teacher announces that the student or group can take a short break (e.g., 2 minutes). When that break is over, students are directed to again begin work. This sequence (work interval, escape interval) repeats until the scheduled work period is over. As students are able successfully to remain engaged during work periods, the teacher can gradually extend the length of these work periods by small increments, while reducing and then fading escape breaks, until work periods reach the desired length.

5. Generalization

Goal. At the beginning of the generalization stage, the student is accurate and fluent in using the target skill but does not always employ the skill where or when needed. The goal of this phase is to motivate the student to apply the skill in the widest possible range of appropriate settings and situations.

Instructional Strategies. The teacher can promote generalization of skills by first identifying the types of situations in which the student should apply the target skill and then programming instructional tasks that replicate or mimic these situations. So the teacher may create lessons in which students can generalize the target skills by interacting with a range of people, working with varied materials, and/or visiting different settings. The teacher can also use explicit prompts to remind students to apply skills in specific situations.

Sample Intervention Idea. For a student who does not always generalize the skill of carefully checking math assignments before turning them in, the teacher can work with that student to create a math *self-*

correction checklist (Uberti, Mastropieri, & Scruggs, 2004). Teacher and student meet to create a checklist of that student's most common sources of errors on math assignments. The student is then expected to use the checklist to review math work before submitting to the teacher. This intervention strategy can be adopted to other disciplines (e.g., writing assignments) as well. And completed checklists can be collected with assignments to verify student use.

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How To: Document Academic & Behavioral Interventions

When general-education students begin to struggle with academic or behavioral issues, the classroom teacher will typically select and implement one or more evidence-based intervention strategies to assist those students. But a strong intervention plan needs more than just well-chosen interventions. It also requires 4 additional components (Witt, VanDerHeyden, & Gilbertson, 2004): (1) student concerns should be clearly and specifically defined; (2) one or more methods of formative assessment should be used to track the effectiveness of the intervention; (3) baseline student data should be collected prior to the intervention; and (4) a goal for student improvement should be calculated before the start of the intervention to judge whether that intervention is ultimately successful. If a single one of these essential 4 components is missing, the intervention is to be judged as fatally flawed (Witt, VanDerHeyden, & Gilbertson, 2004) and as not meeting minimum Response to Intervention standards.

Teachers need a standard format to use in documenting their classroom intervention plans. The *Classroom Intervention Planning Sheet* that appears later in this article is designed to include all of the essential documentation elements of an effective intervention plan. The form includes space to document:

- *Case information*. In this first section of the form, the teacher notes general information, such as the name of the target student, the adult(s) responsible for carrying out the intervention, the date the intervention plan is being created, the expected start and end dates for the intervention plan, and the total number of instructional weeks that the intervention will be in place. Most importantly, this section includes a description of the student problem; research shows that the most significant step in selecting an effective classroom intervention is to correctly identify the target student concern(s) in clear, specific, measureable terms (Bergan, 1995).
- *Intervention.* The teacher describes the evidence-based intervention(s) that will be used to address the identified student concern(s). As a shortcut, the instructor can simply write the intervention name in this section and attach a more detailed intervention script/description to the intervention plan.
- *Materials.* The teacher lists any materials (e.g., flashcards, wordlists, worksheets) or other resources (e.g., Internet-connected computer) necessary for the intervention.
- *Training.* If adults and/or the target student require any training prior to the intervention, the teacher records those training needs in this section of the form.
- *Progress-Monitoring.* The teacher selects a method to monitor student progress during the intervention. For the method selected, the instructor records what type of data is to be used, collects and enters student baseline (starting-point) information, calculates an intervention outcome goal, and notes how frequently he or she plans to monitor the intervention.

A completed example of the *Classroom Intervention Planning Sheet* that includes a math computation intervention can be found later in this article.

While a simple intervention documentation form is a helpful planning tool, schools should remember that teachers will need other resources and types of assistance as well to be successful in selecting and using classroom interventions. For example, teachers should have access to an ‘intervention menu’ that contains evidence-based strategies to address the most common academic and behavioral concerns and should be able to get coaching support as they learn how to implement new classroom intervention ideas.

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Classroom Intervention Planning Sheet

This worksheet is designed to help teachers to quickly create classroom plans for academic and behavioral interventions. (For a tutorial on how to fill out this sheet, review the accompanying directions.)

Case Information

What to Write: Record the important case information, including student, person delivering the intervention, date of plan, start and end dates for the intervention plan, and the total number of instructional weeks that the intervention will run.

Student:		Interventionist(s):		Date Intervention Plan Was Written:	
Date Intervention is to Start:		Date Intervention is to End:		Total Number of Intervention Weeks:	
Description of the Student Problem:					

Intervention

What to Write: Write a brief description of the intervention(s) to be used with this student. TIP: If you have a script for this intervention, you can just write its name here and attach the script to this sheet.

Materials	Training
What to Write: Jot down materials (e.g., flashcards) or resources (e.g., Internet-connected computer) needed to carry out this intervention.	**What to Write:** Note what training--if any--is needed to prepare adult(s) and/or the student to carry out the intervention.

Progress-Monitoring

What to Write: Select a method to monitor student progress on this intervention. For the method selected, record what type of data is to be used, enter student baseline (starting-point) information, calculate an intervention outcome goal, and note how frequently you plan to monitor the intervention. Tip: Several ideas for classroom data collection appear on the right side of this table.

Type of Data Used to Monitor:	
Baseline	Outcome Goal
How often will data be collected? (e.g., daily, every other day, weekly):	

Ideas for Intervention Progress-Monitoring

- Existing data: grades, homework logs, etc.
- Cumulative mastery log
- Rubric
- Curriculum-based measurement
- Behavior report card
- Behavior checklist

Classroom Intervention Planning Sheet: Math Computation Example

This worksheet is designed to help teachers to quickly create classroom plans for academic and behavioral interventions. (For a tutorial on how to fill out this sheet, review the accompanying directions.)

Case Information

What to Write: Record the important case information, including student, person delivering the intervention, date of plan, start and end dates for the intervention plan, and the total number of instructional weeks that the intervention will run.

Student:	*John Samuelson-Gr 4*	Interventionist(s):	*Mrs. Kennedy, classroom teacher*	Date Intervention Plan Was Written:	*10 October 2012*
Date Intervention is to Start:	*M 8 Oct 2012*	Date Intervention is to End:	*F 16 Nov 2012*	Total Number of Intervention Weeks:	*6 weeks*
Description of the Student Problem:	*Slow math computation speed (computes multiplication facts at 12 correct digits in 2 minutes, when typical gr 4 peers compute at least 24 correct digits).*				

Intervention

What to Write: Write a brief description of the intervention(s) to be used with this student. TIP: If you have a script for this intervention, you can just write its name here and attach the script to this sheet.

Math Computation Time Drill.(Rhymer et al., 2002)

Explicit time-drills are a method to boost students' rate of responding on arithmetic-fact worksheets: (1) The teacher hands out the worksheet. Students are instructed that they will have 3 minutes to work on problems on the sheet. (2) The teacher starts the stop watch and tells the students to start work. (3) At the end of the first minute in the 3-minute span, the teacher 'calls time', stops the stopwatch, and tells the students to underline the last number written and to put their pencils in the air. Then students are told to resume work and the teacher restarts the stopwatch. (4) This process is repeated at the end of minutes 2 and 3. (5) At the conclusion of the 3 minutes, the teacher collects the student worksheets.

Materials	Training
What to Write: Jot down materials (e.g., flashcards) or resources (e.g., Internet-connected computer) needed to carry out this intervention.	**What to Write:** Note what training--if any--is needed to prepare adult(s) and/or the student to carry out the intervention.
Use math worksheet generator on www.interventioncentral.org to create all time-drill and assessment materials.	*Meet with the student at least once before the intervention to familiarize with the time-drill technique and timed math computation assessments.*

Progress-Monitoring

What to Write: Select a method to monitor student progress on this intervention. For the method selected, record what type of data is to be used, enter student baseline (starting-point) information, calculate an intervention outcome goal, and note how frequently you plan to monitor the intervention. Tip: Several ideas for classroom data collection appear on the right side of this table.

Type of Data Used to Monitor: *Curriculum-based measurement: math computation assessments: 2 minute single-skill probes*

Baseline	Outcome Goal
12 correct digits per 2 minute probe	*24 correct digits per 2 minute probe*

How often will data be collected? (e.g., daily, every other day, weekly): *WEEKLY*

<u>Ideas for Intervention Progress-Monitoring</u>

- Existing data: grades, homework logs, etc.
- Cumulative mastery log
- Rubric
- Curriculum-based measurement
- Behavior report card
- Behavior checklist

Using Accommodations With General-Education Students: Teacher Guidelines

Classrooms in most schools look pretty much alike, with students sitting at rows of desks attending (more or less) to teacher instruction. But a teacher facing any class knows that behind that group of attentive student faces lies a kaleidoscope of differences in academic, social, self-management, and language skills. For example, recent national test results indicate that well over half of elementary and middle-school students have not yet attained proficiency in mathematics (NAEP, 20011a) or reading (NAEP 2011b). Furthermore, 1 in 10 students now attending American schools is an English Language Learner (Institute of Education Sciences, 2012) who must grapple with the complexities of language acquisition in addition to the demands of academic coursework.

Teachers can increase the chances for academic success by weaving into their instructional routine an appropriate array of classwide curricular accommodations made available to any general-education student who needs them (Kern, Bambara, & Fogt, 2002). However, teachers also know that they must strike an appropriate balance: while accommodations have the potential to help struggling learners to more fully engage in demanding academics, they should not compromise learning by holding a general-education student who accesses them to a lesser performance standard than the rest of the class. After all, students with academic deficits must actually *accelerate* learning to close the skill-gap with peers, so allowing them to do less is simply not a realistic option.

Read on for guidelines on how to select classroom accommodations to promote school success, verify whether a student actually *needs* a particular accommodation, and judge when accommodations should be used in instruction even if not allowed on state tests.

Identifying Appropriate Accommodations: Access vs. Target Skills. As an aid in determining whether a particular accommodation both supports individual student differences and sustains a demanding academic environment, teachers should distinguish between *target* and *access* skills (Tindal, Daesik, & Ketterlin, 2008). *Target skills* are those academic skills that the teacher is actively trying to assess or to teach. Target skills are therefore 'non-negotiable'; the teacher must ensure that these skills are not compromised in the instruction or assessment of any general-education student. For example, a 4th-grade teacher sets as a target skill for his class the development of computational fluency in basic multiplication facts. To work toward this goal, the teacher has his class complete a worksheet of 20 computation problems under timed conditions. This teacher would not allow a typical student who struggles with computation to do fewer than the assigned 20 problems, as this change would undermine the target skill of computational fluency that is the purpose of the assignment.

In contrast, *access skills* are those needed for the student to take part in a class assessment or instructional activity but are not themselves the target of current assessment or instruction. Access skills, therefore, *can* be the focus of accommodations, as altering them may remove a barrier to student participation but will not compromise the academic rigor of classroom activities. For example, a 7th-grade teacher assigns a 5-paragraph essay as an in-class writing assignment. She notes that one student finds the access skill of handwriting to be difficult and aversive, so she instead allows that student the accommodation of writing his essay on a classroom desktop computer. While the access skill (method of text production) is altered, the teacher preserves the integrity of those elements of the assignment that directly address the target skill (i.e., the student must still produce a full 5-paragraph essay).

Matching Accommodations to Students: Look for the 'Differential Boost'. The first principle in using accommodations in general-education classrooms, then, is that they should address access rather than target academic skills. However, teachers may also wish to identify whether an individual actually benefits from a particular accommodation strategy. A useful tool to investigate this question is the 'differential boost' test (Tindal & Fuchs, 1999). The teacher examines a student's performance both with and without the accommodation and asks these 2 questions: (1) Does the student perform significantly better *with* the accommodation than without?, and (2) Does the accommodation boost that particular student's performance substantially *beyond* what could be expected if it were given to all students in the class? If the answer to both questions is YES, there is clear evidence that this student receives a 'differential boost' from the accommodation and that this benefit can be explained as a unique rather than universal response. With such evidence in hand, the teacher should feel confident that the accommodation is an appropriate match for the student. (Of course, if a teacher observes that most or all of a class seems to benefit from a particular accommodation idea, the best course is probably to revise the assignment or assessment activity to incorporate the accommodation!)

For example, a teacher may routinely allocate 20 minutes for her class to complete an in-class writing assignment and finds that all but one of her students are able to complete the assignment adequately within that time. She therefore allows this one student 10 minutes of additional time for the assignment and discovers that his work is markedly better with this accommodation. The evidence shows that, in contrast to peers, the student gains a clear 'differential boost' from the accommodation of extended time because (1) his writing product is substantially improved when using it, while (2) few if any other students appear to need it.

Classroom Accommodations and State Tests: To Allow or Not to Allow? Teachers may sometimes be reluctant to allow a student to access classroom accommodations if the student cannot use those same accommodations on high-stakes state assessments (TIndal & Fuchs, 1999). This view is understandable; teachers do not want students to become dependent on accommodations only to have those accommodations yanked away at precisely the moment when the student needs them most. While the teacher must be the ultimate judge, however, there are 3 good reasons to consider allowing a general-education student to access accommodations in the classroom that will be off-limits during state testing.

1. *Accommodations can uncover 'academic blockers'.* The teacher who is able to identify which student access skills may require instructional accommodations is also in a good position to provide interventions proactively to strengthen those deficient access skills. For example, an instructor might note that a student does poorly on math word problems because that student has limited reading decoding skills. While the teacher may match the student to a peer who reads the word problems aloud (texts read) as a classroom accommodation, the teacher and school can also focus on improving that student's decoding skills so that she can complete similar math problems independently when taking the next state examinations.

2. *Accommodations can promote content knowledge.* Students who receive in-class accommodations are likely to increase their skills and knowledge in the course or subject content substantially beyond the level to be expected without such supports. It stands to reason that individuals whose academic skills have been strengthened through the right mix of classroom accommodations will come to the state tests with greater mastery of the content on which they are to be tested.

3. *Accommodations can build self-confidence.* When students receive classroom accommodations, they are empowered to better understand their unique pattern of learning strengths and weaknesses and the strategies that work best for them. Self-knowledge can build self-confidence. And not only are such students primed to advocate for their own educational needs; they are also well-placed to develop compensatory strategies to manage difficult, high-stakes academic situations where support is minimal--such as on state tests.

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How To: Increase Motivation in Students: High-Probability Requests

Non-compliance is a frequent source of problem classroom behavior--driven by student attempts to escape or avoid challenging academic tasks (Packenham, Shute & Reid, 2004). For instance, when transitioning between educational activities a work-avoidant student may stall in beginning the next assignment. Or, during independent assignments, that same student may run out the clock by dawdling between work items. To increase compliance and work completion, teachers should identify strategies that prevent off-task behaviors but must also continue to hold students accountable for attaining rigorous academic standards.

High-probability requests are one feasible classroom technique that can be effective in motivating students to engage in assigned classwork (Lee, 2006). The teacher first identifies an academic activity in which the student historically shows a low probability of completing because of non-compliance. The teacher then embeds within that low-probability activity an introductory series of simple, brief 'high-probability' requests or tasks that this same student has an established track record of completing (Belfiore, Basile, & Lee, 2008).

As the student completes several embedded high-probability tasks in succession, he or she builds 'behavioral momentum' in responding that increases the likelihood that the student will apply full effort when encountering the 'main event'--the more challenging, low-probability activity. (See the table *Use of High-Probability Requests to Increase Student Compliance: Examples from Research Studies* for descriptions of how high-probability requests have been used successfully in school settings.)

Use of high-probability requests offers the twin advantages of motivating students while encouraging high academic standards. Students can find the experience of completing simple, high-probability tasks to be intrinsically reinforcing--which fuels the behavioral momentum that gives this strategy its power (Lee et al., 2004). At the same time, this approach offers teachers a means of holding non-compliant students to the same high academic expectations as their more cooperative classmates (Belfiore et al., 2008).

A potential instructional advantage of the high-probability request strategy should also be noted. Research suggests that student retention of learned material is heightened if that material is reviewed at intervals of several months or more from the initial learning (Pashler et al., 2007). If teachers are able to fold previously learned academic material (e.g., math

Use of High-Probability Requests to Increase Student Compliance: Examples from Research Studies

Transitioning within academic tasks: Letter/word copying (Lee et al., 2004). During independent work, two 2nd-grade students were directed to copy a letter several times from a model (a preferred, high-probability task) before being asked to copy a whole word from a model (less-preferred, low-probability task).

Transitioning within academic tasks: Math computation (Lee et al., 2004). Three students with IEPs from intermediate grades were presented with flashcards containing math computation problems. The students were to read off and solve each problem, flip the card over to check the actual answer against their solution, and then advance to the next card. For the activity, the teacher first created a series of cards containing low-probability computation problems that were less-preferred because of their difficulty. Then, before each low-probability problem, the teacher inserted flashcards with three easy (more-preferred, high-probability) computation problems.

Transitioning between academic tasks: Independent math assignment (Wehby & Hollahan, 2000). This study focused on a middle-school student who often would not initiate independent math assignments. The teacher compiled a list of high-probability requests related to the independent math assignment that the student would typically responded to--e.g., 'write your name on the worksheet", "pick up your pencil", "take out a sheet of paper for the assignment", "look over the first problem". At the start of the independent seatwork activity, the teacher approached the student and randomly select and deliver 3 requests from the high-probability list. If the student ignored a request, the teacher would simply deliver another from the list until the student had successfully complied with 3 high-probability requests. Then the teacher delivered the less-preferred, low-probability request: "Begin your independent assignment."

computation facts; course vocabulary items) into high-probability requests, they can both boost student work compliance and promote retention of essential skills or knowledge.

Here are more detailed teacher guidelines from Lee (2006) for embedding high-probability requests to build behavioral momentum sufficient to motivate students to tackle less-preferred, low-probability academic activities:

1. *Identify incidents of non-compliant behavior.* The teacher notes academic work-situations that initially have a low probability for completion because of student non-compliance (e.g., writing a journal entry; completing a worksheet with reflective questions tied to a reading assignment). The teacher also determines whether non-compliance in each situation occurs within that task or in transitioning to that task.

2. *List high-probability tasks.* Next, the teacher generates a list of high-probability tasks that the student is likely to comply with. These tasks should be brief (i.e., take 5 seconds or fewer to complete) and should logically link to the low-probability activity. For example, if the low-probability event is getting the student to start the writing of a journal entry (transitioning between academic activities), easy, high-probability tasks associated with beginning the writing task might include 'organize your writing materials', 'write a title', and 'list 3 ideas for the journal entry'. If the low-probability event is having the student complete a worksheet with reflective questions tied to an assigned reading (within-task), sample high-probability tasks associated with the worksheet could include questions asking the student to 'copy the title of this reading', or 'write down one interesting vocabulary term from the first paragraph'.

3. *Create activities with embedded high-probability tasks.* The teacher then reworks the low-probability work-situation to embed within it a series of high-probability tasks. If the target is to get the student to transition efficiently from one activity to another, the teacher inserts 3 high-probability requests at the start of the activity to create behavioral momentum. If the goal is to prod the student to efficiently complete an independent assignment without hesitating between items, the teacher inserts 3 high-probability requests before each challenging item on the assignment.

4. *Introduce the activities.* The teacher rolls out the activities, now retooled to include embedded high-probability tasks or requests. The teacher is careful, when presenting directives aloud to the student, to pace those directives briskly: letting no more than 10 seconds elapse between student completion of one request and teacher delivery of the next request. The teacher should also monitor the student's performance. If the student does not comply quickly with selected high-probability requests, the teacher should replace those requests on future assignments with others that elicit prompt compliance.

The guidelines offered here demonstrate how strategic use of high-probability requests can generate behavioral momentum and prevent compliance problems with individual students. However, teachers may also be able to creatively use high-probability sequences to motivate whole groups or even an entire class. For example, an instructor might decide to intersperse 3 'easy' (high-probability) items between each 'challenge' item on a math computation worksheet to be assigned to all students for independent seatwork. Or a teacher may routinely introduce in-class writing assignments by first verbally directing students to 'take out paper and pen', 'write your name on the paper', and 'copy this journal topic onto your paper'. The crucial factor in group use of high-probability sequences is that the teacher accurately identify what tasks are indeed motivating and likely to build behavioral momentum among the majority of students.

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Building Number Sense Through a Counting Board Game

DESCRIPTION: The student plays a number-based board game to build skills related to 'number sense', including number identification, counting, estimation skills, and ability to visualize and access specific number values using an internal number-line (Siegler, 2009).

MATERIALS:

- *Great Number Line Race!* Form (attached)
- Spinner divided into two equal regions marked "1" and "2" respectively. (NOTE: If a spinner is not available, the interventionist can purchase a small blank wooden block from a crafts store and mark three of the sides of the block with the number "1" and three sides with the number "2".)

INTERVENTION STEPS: A counting-board game session lasts 12 to 15 minutes, with each game within the session lasting 2-4 minutes. Here are the steps:

1. *Introduce the Rules of the Game.* If the student is unfamiliar with the counting board game, interventionist trains the student to play it.

   The student is told that he or she will attempt to beat another player (either another student or the interventionist). The student is then given a penny or other small object to serve as a game piece. The student is told that players takes turns spinning the spinner (or, alternatively, tossing the block) to learn how many spaces they can move on *the Great Number Line Race!* board. Each player then advances the game piece, moving it forward through the numbered boxes of the game-board to match the number "1" or "2" selected in the spin or block toss.

   When advancing the game piece, the player must call out the number of each numbered box as he or she passes over it. For example, if the player has a game piece on box 7 and spins a "2", that player advances the game piece two spaces, while calling out "8" and "9" (the names of the numbered boxes that the game piece moves across during that turn).

   The player who reaches the "10" box first is the winner.

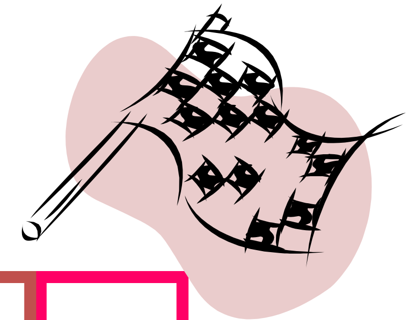
2. *Record Game Outcomes.* At the conclusion of each game, the interventionist records the winner using the form found on the *Great Number Line Race!* form. The session continues with additional games being played for a total of 12-15 minutes.

3. *Continue the Intervention Up to an Hour of Cumulative Play.* The counting-board game continues until the student has accrued a total of at least one hour of play across multiple days. (The amount of cumulative play can be calculated by adding up the daily time spent in the game as recorded on the *Great Number Line Race!* form.)

Reference

Siegler, R. S. (2009). Improving the numerical understanding of children from low-income families. *Child Development Perspectives, 3*(2), 118-124.

The Great Number-Line Race!



Start	1	2	3	4	5	6	7	8	9	10

Date: ______________________ Start Time: _____ : _____ End Time: _____ : _____

Directions: Mark the winner for each game with an 'X' in the table below.

Players	Game 1	Game 2	Game 3	Game 4	Game 5	Game 6	Game 7
1: _________							
2: _________							

Source: Siegler, R. S. (2009). Improving the numerical understanding of children from low-income families. *Child Development Perspectives*, *3*(2), 1

Jim Wright, Presenter www.interventioncentral.org 11

Strategic Number Counting Instruction

DESCRIPTION: The student is taught explicit number counting strategies for basic addition and subtraction. Those skills are then practiced with a tutor (adapted from Fuchs et al., 2009).

MATERIALS:

- Number-line (attached)
- Number combination (math fact) flash cards for basic addition and subtraction
- *Strategic Number Counting Instruction Score Sheet* (attached)

PREPARATION: The tutor trains the student to use these two counting strategies for addition and subtraction:

ADDITION: The student is given a copy of the appropriate number-line (1-10 or 1-20—see attached). When presented with a two-addend addition problem, the student is taught to start with the larger of the two addends and to 'count up' by the amount of the smaller addend to arrive at the answer to the problem.

SUBTRACTION: The student is given a copy of the appropriate number-line (1-10 or 1-20—see attached).. The student is taught to refer to the first number appearing in the subtraction problem (the minuend) as 'the number you start with' and to refer to the number appearing after the minus (subtrahend) as 'the minus number'. The student is directed to start at the minus number on the number-line and to count up to the starting number while keeping a running tally of numbers counted up on his or her fingers. The final tally of digits separating the minus number and starting number is the answer to the subtraction problem.

INTERVENTION STEPS: For each tutoring session, the tutor follows these steps:

1. *Create Flashcards.* The tutor creates addition and/or subtraction flashcards of problems that the student is to practice. Each flashcard displays the numerals and operation sign that make up the problem but leaves the answer blank.

2. *Review Count-Up Strategies*. At the opening of the session, the tutor asks the student to name the two methods for answering a math fact. The correct student response is 'Know it or count up.' The tutor next has the student describe how to count up an addition problem and how to count up a subtraction problem. Then the tutor gives the student two sample addition problems and two subtraction problems and directs the student to solve each, using the appropriate count-up strategy.

3. *Complete Flashcard Warm-Up*. The tutor reviews addition/subtraction flashcards with the student for three minutes. Before beginning, the tutor reminds the student that, when shown a flashcard, the student should try to 'pull the answer from your head'—but that if the student does not know the answer, he or she should use the appropriate count-up strategy. The tutor then reviews the flashcards with the student. Whenever the student makes an error, the tutor directs the student to use the correct count-up strategy to solve. NOTE: If the student cycles through all cards in the stack before the three-minute period has elapsed, the tutor shuffles the cards and begins again.

   At the end of the three minutes, the tutor counts up the number of cards reviewed and records the number of cards that the student (a) identified from memory, (b) solved using the count-up strategy, and (c) was not able to correctly answer. These totals are recorded on the Strategic *Number Counting Instruction Score Sheet*

4. *Repeat Flashcard Review*. The tutor shuffles the math-fact flashcards, encourages the student to try to beat his or her previous score, and again reviews the flashcards with the student for three minutes. As before, whenever the student makes an error, the tutor directs the student to use the appropriate count-up strategy. Also, if the student completes all cards in the stack with time remaining, the tutor shuffles the stack and continues presenting cards until the time is elapsed.

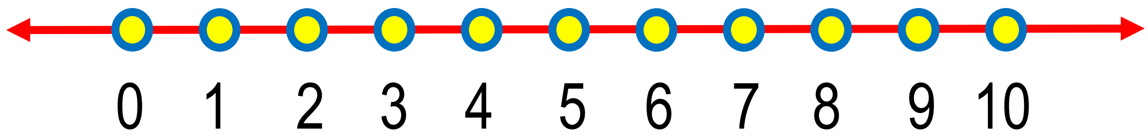
   At the end of the three minutes, the tutor again counts up the number of cards reviewed and records the number of cards that the student (a) identified from memory, (b) solved using the count-up strategy, and (c) was not able to correctly answer. These totals are again recorded on the Strategic *Number Counting Instruction Score Sheet.*

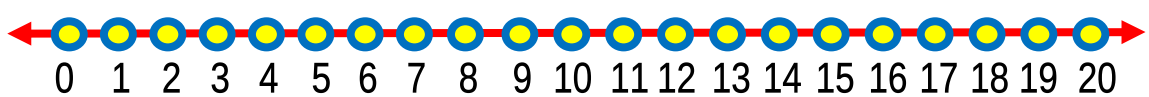
5. *Provide Performance Feedback*. The tutor gives the student feedback about whether (and by how much) the student's performance on the second flashcard trial exceeded the first. The tutor also provides praise if the student beat the previous score or encouragement if the student failed to beat the previous score.

Reference

Fuchs, L. S., Powell, S. R., Seethaler, P. M., Cirino, P. T., Fletcher, J. M., Fuchs, D., & Hamlett, C. L. (2009). The effects of strategic counting instruction, with and without deliberate practice, on number combination skill among students with mathematics difficulties. *Learning and Individual Differences 20*(2), 89-100.

Strategic Number Counting Instruction: Number-Lines





Strategic Number Counting Instruction Score Sheet

Student: ______________________________ Interventionist(s): _________________________________

Directions: During the strategic number counting instruction intervention, use this sheet to tally student responses: Number of Flash-Cards Known From Memory; Number of Flash-Cards Answered Correctly With Count-Up Strategy (with or without assistance); Number of Flash-Cards Unknown or Answered Incorrectly (even with assistance).

Date:________	[Optional] Type/Range of Addition/Subtraction Math-Fact Flash-Cards Reviewed This Session:	
Trial 1: Math Flash-Card Warm-Up: 3 Minutes		
Number of Flash-Cards Known From Memory	Number of Flash-Cards Answered Correctly With Count-Up Strategy	Number of Flash-Cards Unknown or Answered Incorrectly
Trial 2: Math Flash-Card Review: 3 Minutes		
Number of Flash-Cards Known From Memory	Number of Flash-Cards Known From Memory	Number of Flash-Cards Known From Memory

Date:________	[Optional] Type/Range of Addition/Subtraction Math-Fact Flash-Cards Reviewed This Session:	
Trial 1: Math Flash-Card Warm-Up: 3 Minutes		
Number of Flash-Cards Known From Memory	Number of Flash-Cards Answered Correctly With Count-Up Strategy	Number of Flash-Cards Unknown or Answered Incorrectly
Trial 2: Math Flash-Card Review: 3 Minutes		
Number of Flash-Cards Known From Memory	Number of Flash-Cards Known From Memory	Number of Flash-Cards Known From Memory

Math Review: Promote Mastery of Math Facts Through Incremental Rehearsal

Incremental rehearsal builds student fluency in basic math facts ('arithmetic combinations') by pairing unknown computation items with a steadily increasing collection of known items. This intervention makes use of repeated, or massed, practice to promote fluency and guarantees that the student will experience a high rate of success..

Materials

- Index cards and pen

Steps to Implementing This Intervention

In preparation for this intervention:

1. The tutor first writes down on an index card in ink each math fact that a student is expected to master-but without the answer. NOTE: Educators can use the A-Plus Math Flashcard Creator, an on-line application, to make and print flashcards in addition, subtraction, multiplication, and division. The web address for the flashcard creator is: *http://www.aplusmath.com/Flashcards/Flashcard_Creator.html*

2. The tutor reviews the collection of math-fact cards with the student. Any of the math facts that the student can orally answer correctly within two seconds are considered to be known problems and are separated into one pile. Math facts that the student cannot yet answer correctly within two seconds are considered 'unknown' and collected in a second pile -- the 'unknown facts' deck.

3. The tutor next randomly selects 9 cards from the pile of known math facts and sets this subset of cards aside as the 'known facts' deck. The rest of the pile of cards containing known math facts is put away ('discard deck'), not to be used further in this intervention.

During the intervention:

The tutor follows an incremental-rehearsal sequence each day when working with the student:

1. First, the tutor takes a single card from the 'unknown facts' deck. The tutor reads the math fact on the card aloud, provides the answer, and prompts the student to read off and answer the same unknown problem.

2. Next the tutor takes one math fact from the 'known facts' deck and pairs it with the unknown problem. When shown the two problems in sequence, the student is asked during the presentation of each math fact to read off the problem and answer it. The student is judged to be successful on a problem if he or she orally provides the correct answer to that problem within 2 seconds. If the student commits an error on any card or hesitates for longer than two seconds, the tutor reads the math fact on the card aloud, gives the answer, then prompts the

student to read off the same unknown problem and provide the answer. This review sequence continues until the student answers all cards within two seconds without errors.

3. The tutor then repeats the sequence--taking yet another problem from the 'known facts' deck to add to the expanding collection of math facts being reviewed ('review deck'). Each time, the tutor prompts the student to read off and answer the whole series of math facts in the review deck, beginning with the unknown fact and then moving through the growing series of known facts that follow it.

4. When the review deck has expanded to include one 'unknown' math fact followed by nine 'known' math facts (a ratio of 90 percent 'known' material to 10 percent 'unknown' material), the last 'known' math fact that was added to the student's review deck is discarded (put away with the 'discard deck'). The previously 'unknown' math fact that the student has just successfully practiced in multiple trials is now treated as a 'known' math fact and is included as the first item in the nine-card 'known facts' deck for future drills.

5. The student is then presented with a new math fact to answer, taken from the 'unknown facts' deck. With each new 'unknown' math fact, the review sequence is again repeated as described above until the 'unknown' math fact is grouped incrementally with nine math facts from the 'known facts' deck—and on and on.

Daily review sessions are discontinued either when time runs out or when the student answers an 'unknown' math fact incorrectly three times.

Reference

Burns, M. K. (2005). Using incremental rehearsal to increase fluency of single-digit multiplication facts with children identified as learning disabled in mathematics computation. *Education and Treatment of Children, 28*, 237-249.

How To: Improve Proficiency in Math-Facts Through a Self-Administered Folding-In Technique

Students should develop automatic recall of basic math-facts in the elementary grades. Math-fact mastery permits students to shift valuable cognitive capacity away from simple calculations toward higher-level problem-solving (Gersten, Jordan, & Flojo, 2005; National Mathematics Advisory Panel, 2008). An important goal for schools, then, is to ensure that students are proficient in math-facts by the end of grade 5 (Kroesbergen & Van Luit, 2003) to better prepare them for the demanding middle-school math curriculum. Teachers, however, may have difficulty finding instructional time and adult support to deliver math-fact interventions to students.

One solution to this intervention-resource problem is the math-fact self-administered folding-in intervention (math-fact SAFI: Hulac, Dejong, & Benson, 2012). This approach trains students to take charge of their own intervention to acquire and develop fluency in math-facts. Using flash cards, the student reviews math-facts with immediate performance feedback, engages in repeated practice to correct errors, and records on a running log those math-facts that have been mastered. An additional advantage of this intervention is that it has been shown to be effective with middle-school students.

Preparation.

In preparation for this intervention, the teacher creates or obtains the following materials:

- *Math-fact flash cards.* The entire collection of math-facts to be mastered are written onto flash-cards. One fact is written on each card, with the math-fact appearing on the front and the correct answer appearing on the back. For example, multiplication math-facts for 0 through 10 would require 121 flash cards to cover all possible number combinations for this fact-set. Tip: Students can be given a master set of math-facts with answers (e.g., on the blackboard or on a handout) and directed to create their own math-fact cards.

- *Math-Facts SAFI: Student Checklist.* The student receives a copy of this checklist (attached) containing the essential steps of the self-administered intervention. The teacher can use this same checklist to observe the student and evaluate the integrity of the math-fact SAFI.

- *Dry-Erase Board, Markers, and Eraser.* The student uses the dry-erase board to record all answers in the session.

- *Student Log: Mastered Math-facts*. This recording-form (attached) is used by the student to log any math-facts mastered during the intervention.

In preparation for this intervention, the teacher also meets with the student to:

- *inventory those math-facts the student already knows.* The teacher reviews all math-fact cards with the student. The teacher shows each card to the student for 3 seconds. If the student responds correctly to the math-fact, the teacher sorts that card into the "known" stack. If the student answers incorrectly or hesitates for 3 seconds or longer, the teacher sorts the card into the "unknown" stack. The teacher then puts rubber bands around the "known" and "unknown" stacks for student use as outlined below.

- *train the student in the steps of the math-fact SAFI*. Using the intervention materials and *Math-Facts SAFI: Student Checklist,* the teacher trains the student to implement the intervention.

Procedure. Below are the steps the student follows in each session to implement the math-fact self-administered folding-in technique. (NOTE: Because the student is the interventionist, the steps are written as student directions):

1. Start with the daily stack of cards from the last session. Or create a new "daily stack" by taking 7 cards from your weekly "known" stack and 3 cards from your weekly "unknown" stack and shuffling them.
2. Take the first card from the top of the daily stack and place it flat on the table.
3. Read the math-fact on the card and write the answer on the dry-erase board *within 3 seconds.*
4. Turn the card over and compare the answer that you wrote to the answer on the card.
5. If your answer is correct, sort that card into a "daily known" pile. If your answer is incorrect, sort that card into a "daily unknown" pile--then practice by writing the math-fact and correct answer on your dry-erase board three times in a row.
6. Continue until you have answered all 10 daily cards. Then look at the daily "known" and "unknown" card stacks. If all daily cards are in the "known" stack, draw a star in the bottom left corner of your dry-erase board.
7. Shuffle the 10 cards in the daily card deck.
8. Continue reviewing all 10 cards in the daily deck as explained in steps 2-7 until you have drawn three stars in the bottom left corner of the dry-erase board. (In other words, continue until you have answered all 10 cards without error in a single run-through and have accomplished this feat a total of three times in the session.)
9. When you have earned 3 stars, consider the entire daily stack to be "known" cards. So it's now time to update the daily deck.
10. Take any 3 cards from your current daily 10-card deck and transfer them to the weekly "known" deck. Then, on the *Student Log: Mastered Math-facts* form, record the math-facts and current date for the 3 cards that you transfer. Congratulations! These now count as mastered math-facts!
11. Next, take 3 cards from the weekly "unknown" stack and add them to your current daily deck to bring it back up to 10 cards.
12. Begin reviewing the daily stack again (as outlined in steps 2-7) until your time runs out.
13. Before ending the session, place rubber-bands around the weekly "known" and "unknown" decks and the daily stack that you are currently working on. Also, be sure that your *Student Log: Mastered Math-facts* form is up-to-date.

References

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38*, 293-304.

Hulac, D. M., Dejong, K., & Benson, N. (2012). Can students run their own interventions?: A self-administered math fluency intervention. *Psychology in the Schools, 49*, 526-538.

Kroesbergen, E., & Van Luit, J. E. H. (2003). Mathematics interventions for children with special educational needs. *Remedial and Special Education, 24*, 97-114.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* U.S. Department of Education: Washington, D.C.

Math-Facts SAFI: Student Checklist (Hulac, Dejong, & Benson, 2012).	
Carried Out?	*Intervention Step*
__Y __N	1. Start with the daily stack of cards from the last session. Or create a new "daily stack" by taking 7 cards from your weekly "known" stack and 3 cards from your weekly "unknown" stack and shuffling them.
__Y __N	2. Take the first card from the top of the daily stack and place it flat on the table.
__Y __N	3. Read the math-fact on the card and write the answer on the dry-erase board *within 3 seconds.*
__Y __N	4. Turn the card over and compare the answer that you wrote to the answer on the card.
__Y __N	5. If your answer is correct, sort that card into a "daily known" pile. If your answer is incorrect, sort that card into a "daily unknown" pile--then practice by writing the math-fact and correct answer on your dry-erase board three times in a row.
__Y __N	6. Continue until you have answered all 10 daily cards. Then look at the daily "known" and "unknown" card stacks. If all daily cards are in the "known" stack, draw a star in the bottom left corner of your dry-erase board.
__Y __N	7. Shuffle the 10 cards in the daily card deck.
__Y __N	8. Continue reviewing all 10 cards in the daily deck as explained in steps 2-7 until you have drawn three stars in the bottom left corner of the dry-erase board. (In other words, continue until you have answered all 10 cards without error in a single run-through and have accomplished this feat a total of three times in the session.)
__Y __N	9. When you have earned 3 stars, consider the entire daily stack to be "known" cards. So it's now time to update the daily deck.
__Y __N	10. Take any 3 cards from your current daily 10-card deck and transfer them to the weekly "known" deck. Then, on the *Student Log: Mastered Math-facts* form, record the math-facts and current date for the 3 cards that you transfer. Congratulations! These now count as mastered math-facts!
__Y __N	11. Next, take 3 cards from the weekly "unknown" stack and add them to your current daily deck to bring it back up to 10 cards.
__Y __N	12. Begin reviewing the daily stack again (as outlined in steps 2-7) until your time runs out.
__Y __N	13. Before ending the session, place rubber-bands around the weekly "known" and "unknown" decks and the daily stack that you are currently working on. Also, be sure that your *Student Log: Mastered Math-facts* form is up-to-date.

Student Log: Mastered Math-facts

Student: ______________________ School Yr: ______ Classroom/Course: ______________

Directions to the Student: Record any math-facts that you are transferring to the 'known' weekly stack.

Item 1: ______________ Date: ___/___/___	Item 25: ______________ Date: ___/___/___
Item 2: ______________ Date: ___/___/___	Item 26: ______________ Date: ___/___/___
Item 3: ______________ Date: ___/___/___	Item 27: ______________ Date: ___/___/___
Item 4: ______________ Date: ___/___/___	Item 28: ______________ Date: ___/___/___
Item 5: ______________ Date: ___/___/___	Item 29: ______________ Date: ___/___/___
Item 6: ______________ Date: ___/___/___	Item 30: ______________ Date: ___/___/___
Item 7: ______________ Date: ___/___/___	Item 31: ______________ Date: ___/___/___
Item 8: ______________ Date: ___/___/___	Item 32: ______________ Date: ___/___/___
Item 9: ______________ Date: ___/___/___	Item 33: ______________ Date: ___/___/___
Item 10: ______________ Date: ___/___/___	Item 34: ______________ Date: ___/___/___
Item 11: ______________ Date: ___/___/___	Item 35: ______________ Date: ___/___/___
Item 12: ______________ Date: ___/___/___	Item 36: ______________ Date: ___/___/___
Item 13: ______________ Date: ___/___/___	Item 37: ______________ Date: ___/___/___
Item 14: ______________ Date: ___/___/___	Item 38: ______________ Date: ___/___/___
Item 15: ______________ Date: ___/___/___	Item 39: ______________ Date: ___/___/___
Item 16: ______________ Date: ___/___/___	Item 40: ______________ Date: ___/___/___
Item 17: ______________ Date: ___/___/___	Item 41: ______________ Date: ___/___/___
Item 18: ______________ Date: ___/___/___	Item 42: ______________ Date: ___/___/___
Item 19: ______________ Date: ___/___/___	Item 43: ______________ Date: ___/___/___
Item 20: ______________ Date: ___/___/___	Item 44: ______________ Date: ___/___/___
Item 21: ______________ Date: ___/___/___	Item 45: ______________ Date: ___/___/___
Item 22: ______________ Date: ___/___/___	Item 46: ______________ Date: ___/___/___
Item 23: ______________ Date: ___/___/___	Item 47: ______________ Date: ___/___/___
Item 24: ______________ Date: ___/___/___	Item 48: ______________ Date: ___/___/___

Student Log: Mastered Math-facts

Directions to the Student: Record any math-facts that you are transferring to the 'known' weekly stack.

Item 49: ______________________	Date: ___/___/___	Item 75: ______________________	Date: ___/___/___
Item 50: ______________________	Date: ___/___/___	Item 76: ______________________	Date: ___/___/___
Item 51: ______________________	Date: ___/___/___	Item 77: ______________________	Date: ___/___/___
Item 52: ______________________	Date: ___/___/___	Item 78: ______________________	Date: ___/___/___
Item 53: ______________________	Date: ___/___/___	Item 79: ______________________	Date: ___/___/___
Item 54: ______________________	Date: ___/___/___	Item 80: ______________________	Date: ___/___/___
Item 55: ______________________	Date: ___/___/___	Item 81: ______________________	Date: ___/___/___
Item 56: ______________________	Date: ___/___/___	Item 82: ______________________	Date: ___/___/___
Item 57: ______________________	Date: ___/___/___	Item 83: ______________________	Date: ___/___/___
Item 58: ______________________	Date: ___/___/___	Item 84: ______________________	Date: ___/___/___
Item 59: ______________________	Date: ___/___/___	Item 85: ______________________	Date: ___/___/___
Item 60: ______________________	Date: ___/___/___	Item 86: ______________________	Date: ___/___/___
Item 61: ______________________	Date: ___/___/___	Item 87: ______________________	Date: ___/___/___
Item 62: ______________________	Date: ___/___/___	Item 88: ______________________	Date: ___/___/___
Item 63: ______________________	Date: ___/___/___	Item 89: ______________________	Date: ___/___/___
Item 64: ______________________	Date: ___/___/___	Item 90: ______________________	Date: ___/___/___
Item 65: ______________________	Date: ___/___/___	Item 91: ______________________	Date: ___/___/___
Item 66: ______________________	Date: ___/___/___	Item 92: ______________________	Date: ___/___/___
Item 67: ______________________	Date: ___/___/___	Item 93: ______________________	Date: ___/___/___
Item 68: ______________________	Date: ___/___/___	Item 94: ______________________	Date: ___/___/___
Item 69: ______________________	Date: ___/___/___	Item 95: ______________________	Date: ___/___/___
Item 70: ______________________	Date: ___/___/___	Item 96: ______________________	Date: ___/___/___
Item 71: ______________________	Date: ___/___/___	Item 97: ______________________	Date: ___/___/___
Item 72: ______________________	Date: ___/___/___	Item 98: ______________________	Date: ___/___/___
Item 73: ______________________	Date: ___/___/___	Item 99: ______________________	Date: ___/___/___
Item 74: ______________________	Date: ___/___/___	Item 100: _____________________	Date: ___/___/___

Peer Tutoring in Math Computation with Constant Time Delay

DESCRIPTION: This intervention employs students as reciprocal peer tutors to target acquisition of basic math facts (math computation) using constant time delay (Menesses & Gresham, 2009; Telecsan, Slaton, & Stevens, 1999). Each tutoring 'session' is brief and includes its own progress-monitoring component--making this a convenient and time-efficient math intervention for busy classrooms.

MATERIALS:

Student Packet: A work folder is created for each tutor pair. The folder contains:

- ❑ 10 math fact cards with equations written on the front and correct answer appearing on the back. NOTE: The set of cards is replenished and updated regularly as tutoring pairs master their math facts.
- ❑ Progress-monitoring form for each student.
- ❑ Pencils.

PREPARATION: To prepare for the tutoring program, the teacher selects students to participate and trains them to serve as tutors.

Select Student Participants. Students being considered for the reciprocal peer tutor program should at minimum meet these criteria (Telecsan, Slaton, & Stevens, 1999, Menesses & Gresham, 2009):

- ❑ Is able and willing to follow directions;
- ❑ Shows generally appropriate classroom behavior;
- ❑ Can attend to a lesson or learning activity for at least 20 minutes.
- ❑ Is able to name all numbers from 0 to 18 (if tutoring in addition or subtraction math facts) and name all numbers from 0 to 81 (if tutoring in multiplication or division math facts).
- ❑ Can correctly read aloud a sampling of 10 math-facts (equation plus answer) that will be used in the tutoring sessions. (NOTE: The student does not need to have memorized or otherwise mastered these math facts to participate—just be able to read them aloud from cards without errors).
- ❑ [To document a deficit in math computation] When given a two-minute math computation probe to complete independently, computes fewer than 20 correct digits (Grades 1-3) or fewer than 40 correct digits (Grades 4 and up) (Deno & Mirkin, 1977).

NOTE: Teachers may want to use the attached *Reciprocal Peer Tutoring in Math Computation: Teacher Nomination Form* to compile a list of students who would be suitable for the tutoring program.

Train the Student Tutors. Student tutors are trained through explicit instruction (Menesses & Gresham, 2009) with the teacher clearly explaining the tutoring steps, demonstrating them, and then having the students practice the steps with performance feedback and encouragement from the teacher. The teacher also explains, demonstrates, and observes students practice the progress-monitoring component of the program. (NOTE: Teachers can find a handy listing of all the tutoring steps in which students are to be trained on the attached form *Peer Tutoring in Math*

Computation with Constant Time Delay: Integrity Checklist. This checklist can also be used to evaluate the performance of students to determine their mastery of the tutoring steps during practice sessions with the teacher.)

When students have completed their training, the teacher has each student role-play the tutor with the teacher assuming the role of tutee. The tutor-in-training works through the 3-minute tutoring segment and completes the follow-up progress-monitoring activity. The teacher then provides performance feedback. The student is considered to be ready to tutor when he or she successfully implements all steps of the intervention (100% accuracy) on three successive training trials (Menesses & Gresham, 2009).

INTERVENTION STEPS: Students participating in the tutoring program meet in a setting in which their tutoring activities will not distract other students. The setting is supervised by an adult who monitors the students and times the tutoring activities. These are the steps of the tutoring intervention:

1. Complete the Tutoring Activity. In each tutoring pair, one of the students assumes the role of tutor. The supervising adult starts the timer and says 'Begin'; after 3 minutes, the adult stops the timer and says 'Stop'.

   While the timer is running, the tutor follows this sequence:

   a. *Presents Cards*. The tutor presents each card to the tutee for 3 seconds.

   b. *Provides Tutor Feedback*. [When the tutee responds correctly] The tutor acknowledges the correct answer and presents the next card.

      [When the tutee does not respond within 3 seconds or responds incorrectly] The tutor states the correct answer and has the tutee repeat the correct answer. The tutor then presents the next card.

   c. *Provides Praise*. The tutor praises the tutee immediately following correct answers.

   d. *Shuffles Cards*. When the tutor and tutee have reviewed all of the math-fact carts, the tutor shuffles them before again presenting cards.

   e. *Continues to the Timer*. The tutor continues to presents math-fact cards for tutee response until the timer rings.

2. Assess the Progress of the Tutee. The tutor concludes each 3-minute tutoring session by assessing the number of math facts mastered by the tutee. The tutor follows this sequence:

   a. *Presents Cards.* The tutor presents each card to the tutee for 3 seconds.

   b. *Remains Silent*. The tutor does not provide performance feedback or praise to the tutee, or otherwise talk during the assessment phase.

   c. *Sorts Cards*. Based on the tutee's responses, the tutor sorts the math-fact cards into 'correct' and 'incorrect' piles.

d. *Counts Cards and Records Totals*. The tutor counts the number of cards in the 'correct' and 'incorrect' piles and records the totals on the tutee's progress-monitoring chart.

3. Switch Roles. After the tutor has completed the 3-minute tutoring activity and assessed the tutee's progress on math facts, the two students reverse roles. The new tutor then implements steps 2 and 3 described above with the new tutee.

4. Conduct Tutoring Integrity Checks and Monitor Student Performance. As the student pairs complete the tutoring activities, the supervising adult monitors the integrity with which the intervention is carried out. At the conclusion of the tutoring session, the adult gives feedback to the student pairs, praising successful implementation and providing corrective feedback to students as needed. NOTE: Teachers can use the attached form *Peer Tutoring in Math Computation with Constant Time Delay: Integrity Checklist* to conduct integrity checks of the intervention and student progress-monitoring components of the math peer tutoring.

   The adult supervisor also monitors student progress. After each student pair has completed one tutoring cycle and assessed and recorded their progress, the supervisor reviews the score sheets. If a student has successfully answered all 10 math fact cards three times in succession, the supervisor provides that student's tutor with a new set of math flashcards.

References

Deno, S. L., & Mirkin, P. K. (1977). Data-based program modification: A manual. Reston, VA: Council for Exceptional Children.

Menesses, K. F., & Gresham, F. M. (2009). Relative efficacy of reciprocal and nonreciprocal peer tutoring for students at-risk for academic failure. *School Psychology Quarterly, 24*, 266–275.

Telecsan, B. L., Slaton, D. B., & Stevens, K. B. (1999). Peer tutoring: Teaching students with learning disabilities to deliver time delay instruction. *Journal of Behavioral Education, 9*, 133-154.

Reciprocal Peer Tutoring in Math Computation: Teacher Nomination Form

Teacher: ____________________ Classroom: ____________ Date: _____________

Directions: Select students in your class that you believe would benefit from participation in a peer tutoring program to boost math computation skills. Write the names of your student nominees in the space provided below. Remember, students who are considered for the peer tutoring program should—*at minimum*—meet these criteria:

- Show generally appropriate classroom behaviors and follow directions.
- Can pay attention to a lesson or learning activity for at least 20 minutes.
- Are able to wait appropriately to hear the correct answer from the tutor if the student does not know the answer.
- When given a two-minute math computation probe to complete independently, computes **fewer** than 20 correct digits (Grades 1-3) or **fewer** than 40 correct digits (Grades 4 and up) (Deno & Mirkin, 1977).
- Can name all numbers from 0 to 18 (if tutoring in addition or subtraction math facts) and name all numbers from 0 to 81 (if tutoring in multiplication or division math facts).
- Can correctly read aloud a sampling of 10 math-facts (equation plus answer) that will be used in the tutoring sessions. (NOTE: The student does not need to have memorized or otherwise mastered these math facts to participate—just be able to read them aloud from cards without errors).

Number	Student Name	NOTES
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Peer Tutoring in Math Computation with Constant Time Delay: Integrity Checklist			
Tutoring Session: Intervention Phase			
Directions: Observe the tutor and tutee for a full intervention session. Use this checklist to record whether each of the key steps of the intervention were correctly followed.			
Correctly Carried Out?	Step	Tutor Action	NOTES
___ Y ___ N	1.	**Promptly Initiates Session.** At the start of the timer, the tutor immediately presents the first math-fact card.	
___ Y ___ N	2.	**Presents Cards.** The tutor presents each card to the tutee for 3 seconds.	
___ Y ___ N	3.	**Provides Tutor Feedback.** [When the tutee responds correctly] The tutor acknowledges the correct answer and presents the next card. [When the tutee does not respond within 3 seconds or responds incorrectly] The tutor states the correct answer and has the tutee repeat the correct answer. The tutor then presents the next card.	
___ Y ___ N	4.	**Provides Praise.** The tutor praises the tutee immediately following correct answers.	
___ Y ___ N	5.	**Shuffles Cards.** When the tutor and tutee have reviewed all of the math-fact carts, the tutor shuffles them before again presenting cards.	
___ Y ___ N	6.	**Continues to the Timer.** The tutor continues to presents math-fact cards for tutee response until the timer rings.	

Tutoring Session: Assessment Phase			
Directions: Observe the tutor and tutee during the progress-monitoring phase of the session. Use this checklist to record whether each of the key steps of the assessment were correctly followed.			
Correctly Carried Out?	Step	Tutor Action	NOTES
___ Y ___ N	1.	**Presents Cards.** The tutor presents each card to the tutee for 3 seconds.	
___ Y ___ N	2.	**Remains Silent.** The tutor does not provide performance feedback or praise to the tutee, or otherwise talk during the assessment phase.	
___ Y ___ N	3.	**Sorts Cards.** The tutor sorts cards into 'correct' and 'incorrect' piles based on the tutee's responses.	
___ Y ___ N	4.	**Counts Cards and Records Totals.** The tutor counts the number of cards in the 'correct' and 'incorrect' piles and records the totals on the tutee's progress-monitoring chart.	

Math Tutoring: Score Sheet

Tutor 'Coach': _________________________ Tutee 'Player': _________________________

Directions to the Tutor: Write down the number of math-fact cards that your partner answered *correctly* and the number answered *incorrectly*.

Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:
Date:	Cards Correct:	Cards Incorrect:

Increase Student Math Success with Customized Math Self-Correction Checklists

DESCRIPTION: The teacher analyzes a particular student's pattern of errors commonly made when solving a math algorithm (on either computation or word problems) and develops a brief error self-correction checklist unique to that student. The student then uses this checklist to self-monitor—and when necessary correct—his or her performance on math worksheets before turning them in.

MATERIALS:

- Customized student math error self-correction checklist (described below)
- Worksheets or assignments containing math problems matched to the error self-correction checklist

INTERVENTION STEPS: The intervention with customized math error self-correction checklists includes these steps (adapted from Dunlap & Dunlap, 1989; Uberti et al., 2004):

1. *Develop the Checklist*. The teacher draws on multiple sources of data available in the classroom to create a list of errors that the student commonly makes on a specific type of math computation or word problem. Good sources of information for analyzing a student's unique pattern of math-related errors include review of completed worksheets and other work products, interviewing the student, asking the student to solve a math problem using a 'think aloud' approach to walk through the steps of an algorithm, and observing the student completing math problems in a cooperative learning activity with other children.

   Based on this error analysis, the teacher creates a short (4-to-5 item) student self-correction checklist that includes the most common errors made by that student. Items on the checklist are written in the first person and when possible are stated as 'replacement' or goal behaviors. This checklist might include steps in an algorithm that challenge the student (e.g., "I underlined all numbers at the top of the subtraction problem that were smaller than their matching numbers at the bottom of the problem") as well as goals tied to any other errors that impede math performance (e.g., "I wrote all numbers carefully so that I could read them easily and not mistake them for other numbers").

   NOTE: To reduce copying costs, the teacher can laminate the self-correction checklist and provide the student with an erasable marker to allow for multiple re-use of the form.

2. *Introduce the Checklist.* The teacher shows the student the self-correction checklist customized for that student. The teacher states that the student is to use the checklist to check his or her work before turning it in so that the student can identify and correct the most common errors.

3. *Prompt the Student to Use the Checklist to Evaluate Each Problem.* The student is directed to briefly review all items on the checklist before starting any worksheet or assignment containing the math problems that it targets.

   When working on the math worksheet or assignment, the student uses the checklist after *every* problem to check his or her work—marking each checklist item with a plus sign ('+') if correctly followed or a minus sign ('-') if not correctly followed. If any checklist item receives a minus rating, the student is directed to leave the original solution to the problem untouched, to solve the problem again, and again to use the checklist to check the work. Upon finishing the assignment, the student turns it in, along with the completed self-correction checklists.

4. *Provide Performance Feedback, Praise, and Encouragement*. Soon after the student submits any math worksheets associated with the intervention, the teacher should provide him or her with timely feedback about errors, praise for correct responses, and encouragement to continue to apply best effort.

5. *[OPTIONAL] Provide Reinforcement for Checklist Use*. If the student appears to need additional incentives to increase motivation for the intervention, the teacher can assign the student points for intervention compliance: (1) the student earns one point on any assignment for each correct answer, and (2) the student earns an additional point for each problem on which the student committed none of the errors listed on the self-correction checklist. The student is allowed to collect points and to redeem them for privileges or other rewards in a manner to be determined by the teacher.

6. *Fade the Intervention*. The error self-correction checklist can be discontinued when the student is found reliably to perform on the targeted math skill(s) at a level that the teacher defines as successful (e.g., 90 percent success or greater).

Reference

Dunlap, L. K., & Dunlap, G. (1989). A self-monitoring package for teaching subtraction with regrouping to students with learning disabilities. *Journal of Applied Behavior Analysis, 229*, 309-314.

Uberti, H. Z., Mastropieri, M. A., & Scruggs, T. E. (2004). Check it off: Individualizing a math algorithm for students with disabilities via self-monitoring checklists. *Intervention in School and Clinic, 39*(5), 269-275.

SAMPLE: Math Self-Correction Checklist

Student Name: ________________________ Date: ____________________

Rater: Student ________________________ Classroom: ____________________

Directions: To the Student: BEFORE YOU START: Look at each of these goals for careful math work before beginning your assignment. AFTER EACH PROBLEM: Stop and rate YES or NO whether you performed each goal correctly.

	Problem#1	Problem#2	Problem#3	Problem#4	Problem#5
I underlined all numbers at the top of the subtraction problem that were smaller than their matching numbers at the bottom of the problem. Did the student succeed in this behavior goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N
I wrote all numbers carefully so that I could read them easily and not mistake them for other numbers. Did the student succeed in this behavior goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N
I lined up all numbers in the right place-value columns. Did the student succeed in this behavior goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N
I rechecked all of my answers. Did the student succeed in this behavior goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N

Math Self-Correction Checklist

Student Name: ______________________________ Date: ______________________________

Rater: Student ______________________________ Classroom: ______________________________

Directions: To the Student: BEFORE YOU START: Look at each of these goals for careful math work before beginning your assignment. AFTER EACH PROBLEM: Stop and rate YES or NO whether you performed each goal correctly.

	Problem#1	Problem#2	Problem#3	Problem#4	Problem#5
______________________________ Did the student succeed in this math goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N
______________________________ Did the student succeed in this math goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N
______________________________ Did the student succeed in this math goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N
______________________________ Did the student succeed in this math goal? ❑ YES ❑ NO	__Y __N	__Y __N	__Y __N	__Y __N	__Y __N

How To: Assess Early Math Difficulties in the Primary Grades With CBM

In the early elementary grades, students' success in mathematics can be predicted by assessing their acquisition and use of foundation numeracy skills (Gersten, Jordan, & Flojo, 2005). The term *number sense* is often used as short-hand to describe a child's emerging grasp of fundamental mathematical concepts such as what numbers mean, how sets of objects can be described in numerical terms, counting, and simple operations of mental arithmetic (Chard et al, 2005). *Number sense* is difficult to define with precision because the descriptor encompasses a wide range of early math skills (Clarke & Shinn, 2004). By the time a student has entered kindergarten or 1st grade, however, this term can be framed more concretely as a student's ability to access and use a mental number-line.

In the primary grades, the Common Core State Standards in Mathematics are built on the assumption that the successful math student can rapidly access a mental number line for use in such applied mathematical tasks as counting, making accurate comparisons between number, and estimating amounts. For example, a Kindergarten Counting & Cardinality standard (CCSM.K.CC.2) states that a student will "count forward beginning from a given number within the known sequence (instead of having to begin at 1)." (National Governors Association Center for Best Practices et al., 2010; p. 11). Similarly, a Grade 1 standard for Number & Operations in Base 10 (CCSM.1.NBT.1) sets as a student goal to "count to 120, starting at any number less than 120. " (National Governors Association Center for Best Practices et al., 2010; p. 15). Clearly, these and other math standards for the early grades must depend on students' ability to envision and mentally manipulate an internal number-line.

Early Math Fluency Measures: What They Are. Teachers at the primary level have a pressing need for screening tools that can quickly identify those students who require additional instructional support to address deficient number-sense skills. Early Math Fluency measures are one useful means to assess the strength of a young student's 'number sense' (Chard, et al., 2005) and serve as good predictors of mathematical readiness at Kindergarten and Grade 1. Early Math Fluency measures are examples of Curriculum-Based Measurement (Hosp, Hosp, & Howell, 2007) and include Quantity Discrimination, Missing Number, and Number Identification. All Early Math Fluency assessments have an administration time of 1 minute. Here are brief descriptions for three of these measures:

- *Quantity Discrimination:* The student is presented with pairs of numbers randomly sampled from 1-20 and must identify the larger number in each pair.
- *Missing Number:* The student is presented with response items consisting of 3 sequential numbers with one of those numbers randomly left blank. (Each 3-number series is randomly generated from the pool of numbers 1-20.) The student attempts to name the missing number in each series.
- *Number Identification*: The student is presented with a randomly generated series of numbers ranging from 1-20 and names as many of those numbers aloud as time allows.

Early Math Fluency Measures: How to Access Resources. Teachers who would like to screen their Kindergarten and Grade 1 students for possible number-sense delays can obtain these free Early Math Fluency assessment resources: (1) materials for assessment, (2) guidelines for administration and scoring, and (3) research-based norms.

- *Materials for assessment*. Schools can create their own CBM Early Math Fluency assessment materials at no cost, using NumberFly, a free online application:

http://www.interventioncentral.org/tools/early-math-fluency-generator

- *Guidelines for administration and scoring.* The following sets of instructions for preparing, administering, and scoring Early Math Fluency assessments appear later in this document:

    - *Early Math Fluency/Quantity Discrimination: Guidelines for Use*
    - *Math Fluency/Missing Number: Guidelines for Use*
    - *Math Fluency/Number Identification: Guidelines for Use*

- *Research-based norms.* A table, *Curriculum-Based Measurement: Early Mathematics Fluency Norms*, is included in this document. These fluency benchmarks were researched by Chard et al. (2005) and provide Fall/Winter/Spring screening norms for Quantity Discrimination, Missing Number, and Number Identification.

References

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Early Math Fluency/Quantity Discrimination: Guidelines for Use

This introduction to the Quantity Discrimination probe provides information about the preparation, administration, and scoring of this Early Math CBM measure. Additionally, it offers brief guidelines for integrating this assessment into a school-wide 'Response-to-Intervention' model.

Quantity Discrimination: Description (Clarke & Shinn, 2004; Gersten, Jordan & Flojo, 2005)

The student is given a sheet containing pairs of numbers. In each number pair, one number is larger than the other. The numbers in each pair are selected from within a predefined range (e.g., no lower than 1 and no higher than 20). During a one-minute timed assessment, the student identifies the larger number in each pair, completing as many items as possible while the examiner records any Quantity Discrimination errors.

Quantity Discrimination: Preparation

The following materials are needed to administer Quantity Discrimination (QD) Early Math CBM probes:

- Student and examiner copies of a QD assessment probe. (Note: Customized QD probes can be created conveniently and at no cost using Numberfly, a web-based application. Visit Numberfly at *http://www.interventioncentral.org/php/numberfly/numberfly.php*).
- A pencil, pen, or marker
- A stopwatch

Quantity Discrimination: Directions for Administration

1. The examiner sits with the student in a quiet area without distractions. The examiner sits at a table across from the student.

2. The examiner says to the student:

   "The sheet on your desk has pairs of numbers. In each set, one number is bigger than the other."

   "When I say, 'start,' tell me the name of the number that is larger in each pair. Start at the top of this page and work across the page [demonstrate by pointing]. *Try to figure out the larger number for each example.. When you come to the end of a row, go to the next row. Are there any questions?* [Pause] *Start. "*

   NOTE: If the student has difficulties with speech production, the examiner can use this alternate wording for directions: *"When I say, 'start,' point to the number that is larger in each pair"*

3. The examiner begins the stopwatch when the student responds aloud to the first item. If the student hesitates on a number for 3 seconds or longer on a Quantity Discrimination item, the examiner says, *"Go to the next one."* (If necessary, the examiner points to the next number as a student prompt.)

4. The examiner marks each Quantity Discrimination error by marking a slash (/) through the incorrect response item on the examiner form.

5. At the end of one minute, the examiner says, *"Stop"* and writes in a right-bracket symbol ( ]) on the examiner form after the last item that the student had attempted when the time expired. The examiner then collects the student Quantity Discrimination sheet.

6. *Initial Assessment:* If the examiner is assessing the student for the first time, the examiner administers a total of 3 QD probes during the session using the above procedures and takes the median (middle) score as the best estimate of the student's QD skills.
   Progress-Monitoring: If the examiner is monitoring student growth in QD (and has previously collected QD data), only one QD probe is given in the session.

Quantity Discrimination: Directions for Practice

If the student is not yet familiar with QD probes, the teacher can administer one or more practice assessments (using the administration guidelines above) and provide coaching and feedback as needed until assured that the student fully understands the assessment.

Quantity Discrimination: Scoring Guidelines

Correct QD responses include:

- Quantity Discriminations read correctly
- Quantity Discriminations read incorrectly but corrected by the student within 3 seconds

Incorrect QD responses include:

- The student's reading the smaller number in the QD number pair
- Correct QD responses given after hesitations of 3 seconds or longer
- The student's calling out a number other than appears in the QD number pair
- Response items skipped by the student

To calculate a Quantity Discrimination fluency score, the examiner:

1. counts up all QD items that the student attempted to answer and
2. subtracts the number of QD errors from the total number attempted.
3. The resulting figure is the number of correct Quantity Discrimination items completed.(QD fluency score).

Quantity Discrimination Probes as Part of a Response to Intervention Model

- Universal Screening: To proactively identify children who may have deficiencies in development of foundation math concepts, or 'number sense' (Berch, 2005), schools may choose to screen all kindergarten and first grade students using Quantity Discrimination probes. Those screenings would take place in fall, winter, and spring. Students who fall below the 'cutpoint' of the 35th percentile (e.g., Gersten, Jordan & Flojo, 2005).of the grade norms on the QD task would be identified as having moderate deficiencies and given additional interventions to build their 'number sense' skills.

- Tier I (Classroom-Based) Interventions: Teachers can create Quantity Discrimination probes and use them independently to track the progress of students who show modest delays in their math foundation skills.

- Tier II (Individualized) Interventions. Students with more extreme academic delays may be referred to a school-based problem-solving team, which will develop more intensive, specialized interventions to target the student's academic deficits (Wright, 2007). Quantity Discrimination probes can be used as one formative measure to track student progress with Tier II interventions to build foundation math skills.

Quantity Discrimination: Measurement Statistics

Test-Retest Reliability Correlations for Quantity Discrimination Probes		
Time Span	*Correlation*	*Reference*
13-week interval	0.85	Clarke & Shinn (2004)
26-week interval	0.86	Clarke & Shinn (2004)

Predictive Validity Correlations for Quantity Discrimination Probes		
Predictive Validity Measure	*Correlation*	*Reference*
Curriculum-Based Measurement Math Computation Fluency Probes: Grade 1 Addition & Subtraction (Fall Administration of QD Probe and Spring Administration of Math Computation Probe)	0.67	Clarke & Shinn (2004)
Woodcock-Johnson Tests of Achievement: Applied Problems subtest (Fall Administration of QD Probe and Spring Administration of WJ-ACH subtest)	0.79	Clarke & Shinn (2004)
Number Knowledge Test	0.53	Chard, Clarke, Baker, Otterstedt, Braun & Katz.(2005) cited in Gersten, Jordan & Flojo (2005)

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Early Math Fluency/Missing Number: Guidelines for Use

This introduction to the Missing Number probe provides information about the preparation, administration, and scoring of this Early Math CBM measure. Additionally, it offers brief guidelines for integrating this assessment into a school-wide 'Response-to-Intervention' model.

Missing Number: Description (Clarke & Shinn, 2004; Gersten, Jordan & Flojo, 2005)

The student is given a sheet containing multiple number series. Each series consists of 3-4 numbers that appear in sequential order. The numbers in each short series are selected to fall within a predefined range (e.g., no lower than 1 and no higher than 20). In each series, one number is left blank (e.g., '1 2 _ 4').During a one-minute timed assessment, the student states aloud the missing number in as many response items as possible while the examiner records any Missing Number errors.

Missing Number: Preparation

The following materials are needed to administer Missing Number (MN) Early Math CBM probes:

- Student and examiner copies of a MN assessment probe. (Note: Customized MN probes can be created conveniently and at no cost using Numberfly, a web-based application. Visit Numberfly at *http://www.interventioncentral.org/php/numberfly/numberfly.php*).
- A pencil, pen, or marker
- A stopwatch

Missing Number: Directions for Administration

1. The examiner sits with the student in a quiet area without distractions. The examiner sits at a table across from the student.
2. The examiner says to the student:

   "The sheet on your desk has sets of numbers. In each set, a number is missing."

   "When I say, 'start,' tell me the name of the number that is missing from each set of numbers. Start at the top of this page and work across the page [demonstrate by pointing]. *Try to figure out the missing number for each example.. When you come to the end of a row, go to the next row. Are there any questions?* [Pause] *Start. "*

   NOTE: If the student has difficulties with speech production, the examiner can give the student a pencil and use this alternate wording for directions: *"When I say, 'start, write in the number that is missing from each set of numbers."*
3. The examiner begins the stopwatch when the student reads the first number aloud. If the student hesitates on a number for 3 seconds or longer on a Missing Number item, the examiner says the correct number aloud and says, *"Go to the next one."* (If necessary, the examiner points to the next number as a student prompt.)
4. The examiner marks each Missing Number error by marking a slash (/) through the incorrect response item on the examiner form.

5. At the end of one minute, the examiner says, *“Stop”* and writes in a right-bracket symbol ( ]) on the examiner form after the last item that the student had attempted when the time expired. The examiner then collects the student Missing Number sheet.
6. *Initial Assessment:* If the examiner is assessing the student for the first time, the examiner administers a total of 3 MN probes during the session using the above procedures and takes the median (middle) score as the best estimate of the student's MN skills.
   Progress-Monitoring: If the examiner is monitoring student growth in MN (and has previously collected MN data), only one MN probe is given in the session.

Missing Number: Directions for Practice

If the student is not yet familiar with MN assessments, the teacher can administer one or more practice MN probes (using the administration guidelines above) and provide coaching and feedback as needed until assured that the student fully understands the assessment.

Missing Number: Scoring Guidelines

Correct MN responses include:

- Missing numbers read correctly
- Missing numbers read incorrectly but corrected by the student within 3 seconds

Incorrect MN responses include:

- Missing numbers read incorrectly
- Missing numbers read correctly after hesitations of 3 seconds or longer
- Response items skipped by the student

To calculate a Missing Number fluency score, the examiner:

1. counts up all MN items that the student attempted to read aloud and
2. subtracts the number of MN errors from the total number attempted.
3. The resulting figure is the number of correct Missing Number items completed.(MN fluency score).

Missing Number Probes as Part of a Response to Intervention Model

- Universal Screening: To proactively identify children who may have deficiencies in development of foundation math concepts, or ‘number sense’ (Berch, 2005), schools may choose to screen all kindergarten and first grade students using Missing Number probes. Those screenings would take place in fall, winter, and spring. Students who fall below the ‘cutpoint’ of the 35th percentile (e.g., Gersten, Jordan & Flojo, 2005).of the grade norms on the MN task would be identified as having moderate deficiencies and given additional interventions to build their ‘number sense’ skills.

- Tier I (Classroom-Based) Interventions: Teachers can create Missing Number probes and use them independently to track the progress of students who show modest delays in their math foundation skills.

- Tier II (Individualized) Interventions. Students with more extreme academic delays may be referred to a school-based problem-solving team, which will develop more intensive, specialized interventions to target the student’s academic deficits (Wright, 2007). Missing Number probes can be used as one formative measure to track student progress with Tier II interventions to build foundation math skills.

Missing Number: Measurement Statistics

Test-Retest Reliability Correlations for Missing Number Probes		
Time Span	*Correlation*	*Reference*
13-week interval	0.79	Clarke & Shinn (2004)
26-week interval	0.81	Clarke & Shinn (2004)

Predictive Validity Correlations for Missing Number Probes		
Predictive Validity Measure	*Correlation*	*Reference*
Curriculum-Based Measurement Math Computation Fluency Probes: Grade 1 Addition & Subtraction (Fall Administration of MN Probe and Spring Administration of Math Computation Probe)	0.67	Clarke & Shinn (2004)
Woodcock-Johnson Tests of Achievement: Applied Problems subtest (Fall Administration of MNF Probe and Spring Administration of WJ-ACH subtest)	0.72	Clarke & Shinn (2004)
Number Knowledge Test	0.61	Chard, Clarke, Baker, Otterstedt, Braun & Katz.(2005) cited in Gersten, Jordan & Flojo (2005)

References

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Early Math Fluency/Number Identification: Guidelines for Use

This introduction to the Number Identification probe provides information about the preparation, administration, and scoring of this Early Math CBM measure. Additionally, it offers brief guidelines for integrating this assessment into a school-wide 'Response-to-Intervention' model.

Number Identification: Description (Clarke & Shinn, 2004; Gersten, Jordan & Flojo, 2005)
The student is given a sheet containing rows of randomly generated numbers (e.g., ranging from 1 to 20). During a one-minute timed assessment, the student reads aloud as many numbers as possible while the examiner records any Number Identification errors.

Number Identification: Preparation
The following materials are needed to administer Number Identification (NID) Early Math CBM probes:

- Student and examiner copies of a NID assessment probe. (**Note:** Customized NID probes can be created conveniently and at no cost using Numberfly, a web-based application. Visit Numberfly at *http://www.interventioncentral.org/php/numberfly/numberfly.php*).
- A pencil, pen, or marker
- A stopwatch

Number Identification: Directions for Administration

1. The examiner sits with the student in a quiet area without distractions. The examiner sits at a table across from the student.

2. The examiner says to the student:

   "The sheet on your desk has rows of numbers."

   "When I say, 'start,' begin reading the numbers aloud. Start at the top of this page and read across the page [demonstrate by pointing]. *Try to read each number. When you come to the end of a row, go to the next row. Are there any questions?* [Pause] *Start. "*

3. The examiner begins the stopwatch when the student reads the first number aloud. If the student hesitates on a number for 3 seconds or longer, the examiner says, *"Go to the next one."* (If necessary, the examiner points to the next number as a student prompt.)

4. The examiner marks each Number Identification error by marking a slash (/) through the incorrectly read number on the examiner form.

5. At the end of one minute, the examiner says, *"Stop"* and writes in a right-bracket symbol ( ]) on the examiner form from the point in the number series that the student had reached when the time expired. The examiner then collects the student Number Identification sheet.

6. *Initial Assessment:* If the examiner is assessing the student for the first time, the examiner administers a total of 3 NID probes during the session using the above procedures and takes the median (middle) score as the best estimate of the student's NID skills.
   Progress-Monitoring: If the examiner is monitoring student growth in NID (and has previously collected NID data), only one NID probe is given in the session.

Number Identification: Directions for Practice

If the student is not yet familiar with NID assessments, the teacher can administer one or more practice NID probes (using the administration guidelines above) and provide coaching and feedback as needed until assured that the student fully understands the assessment.

Number Identification: Scoring Guidelines

Correct NID responses include:

- Numbers read correctly
- Numbers read incorrectly but corrected by the student within 3 seconds

Incorrect NID responses include:

- Numbers read incorrectly
- Numbers read correctly after hesitations of 3 seconds or longer
- Numbers skipped by the student

To calculate a Number Identification fluency score, the examiner:

1. counts up all numbers that the student attempted to read aloud and
2. subtracts the number of errors from the total of numbers attempted.
3. The resulting figure is the number of correct numbers identified.(NID fluency score).

Number Identification Probes as Part of a Response to Intervention Model

- Universal Screening: To proactively identify children who may have deficiencies in development of foundation math concepts, or 'number sense' (Berch, 2005), schools may choose to screen all kindergarten and first grade students using Number Identification probes. Those screenings would take place in fall, winter, and spring. Students who fall below the 'cutpoint' of the 35th percentile (e.g., Jordan & Hanich, 2003).of the grade norms on the NID task would be identified as having moderate deficiencies and given additional interventions to build their 'number sense' skills.

- Tier I (Classroom-Based) Interventions: Teachers can create Number Identification probes and use them independently to track the progress of students who show modest delays in their math foundation skills.

- Tier II (Individualized) Interventions. Students with more extreme academic delays may be referred to a school-based problem-solving team, which will develop more intensive, specialized interventions to target the student's academic deficits (Wright, 2007). Number Identification probes can be used as one formative measure to track student progress with Tier II interventions to build foundation math skills.

Number identification: Measurement Statistics

Test-Retest Reliability Correlations for Number Identification Probes		
Time Span	*Correlation*	*Reference*
13-week interval	0.85	Clarke & Shinn (2004)
26-week interval	0.76	Clarke & Shinn (2004)

Predictive Validity Correlations for Number Identification Probes		
Predictive Validity Measure	*Correlation*	*Reference*
Curriculum-Based Measurement Math Computation Fluency Probes: Grade 1 Addition & Subtraction (Fall Administration of MN Probe and Spring Administration of Math Computation Probe)	0.60	Clarke & Shinn (2004)
Woodcock-Johnson Tests of Achievement: Applied Problems subtest (Fall Administration of NID Probe and Spring Administration of WJ-ACH subtest)	0.72	Clarke & Shinn (2004)
Number Knowledge Test	0.58	Chard, Clarke, Baker, Otterstedt, Braun & Katz.(2005) cited in Gersten, Jordan & Flojo (2005)

References

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Curriculum-Based Measurement: Early Mathematics Fluency Norms (Chard, Clarke, Baker, Otterstedt, Braun, & Katz, 2005)*

CBM-Early Mathematics Fluency measures assess the strength of a student's 'number sense' (Chard, et al., 2005) and are good predictors of mathematical readiness at Kindergarten and Grade 1. Early Math Fluency measures include Quantity Discrimination, Missing Number, and Number Identification. All Early Math Fluency assessments have an administration time of 1 minute.

Quantity Discrimination (QD): 1 Minute: The student is presented with pairs of numbers randomly sampled from 1-20 and must identify the larger number in each pair.

Grade	Fall QD (Chard et al., 2005)	Fall:+/-1 SD (≈16th%ile to 84th%ile)	Winter QD (Chard et al., 2005)	Winter: +/-1 SD (≈16th%ile to 84th%ile)	Spring QD (Chard et al., 2005)	Spring: +/-1 SD (≈16th%ile to 84th%ile)	Weekly Growth
K	15	8↔22	20	8↔32	23	12↔34	0.25
1	23	16↔30	30	21↔39	37	28↔46	0.44

Missing Number (MN): 1 Minute: The student is presented with response items consisting of 3 sequential numbers with one of those numbers randomly left blank. (Each 3-number series is randomly generated from the pool of numbers 1-20.) The student attempts to name the missing number in each series.

Grade	Fall MN (Chard et al., 2005)	Fall: +/-1 SD (≈16th%ile to 84th%ile)	Winter MN (Chard et al., 2005)	Winter: +/-1 SD (≈16th%ile to 84th%ile)	Spring MN (Chard et al., 2005)	Spring: +/-1 SD (≈16th%ile to 84th%ile)	Weekly Growth
K	3	0↔7	10	3↔17	14	7↔21	0.34
1	9	3↔15	17	11↔23	20	14↔26	0.34

Number Identification (NID): 1 Minute: The student is presented with a randomly generated series of numbers ranging from 1-20 and names as many of those numbers aloud as time allows.

Grade	Fall NID (Chard et al., 2005)	Fall: +/-1 SD (≈16th%ile to 84th%ile)	Winter NID (Chard et al., 2005)	Winter: +/-1 SD (≈16th%ile to 84th%ile)	Spring NID (Chard et al., 2005)	Spring: +/-1 SD (≈16th%ile to 84th%ile)	Weekly Growth
K	14	0↔28	45	27↔63	56	38↔74	1.31
1	34	18↔50	53	36↔70	62	46↔78	0.88

Reference: Chard, D. J., Clarke, B., Baker, S., Otterstedt, J., Braun, D., & Katz, R. (2005). Using measures of number sense to screen for difficulties in mathematics: Preliminary findings. *Assessment for Effective Intervention, 30*(3), 3-14.

***Reported Characteristics of Student Sample(s) Used to Compile These Norms:** *Number of Students Assessed:* Kindergarten: 168; Grade 1: 207/*Geographical Location:* Pacific Northwest: Sample drawn from 7 elementary schools in one district of 5500 students/ *Socioeconomic Status:* Students qualifying for free and reduced lunch: Range of 27% to 69% across 7 participating schools/*Ethnicity:* District population: 13% minorities/*ELLs:* District Population: 4% English Language Learners

Where to Find Materials: Schools can create their own CBM Early Math Fluency assessment materials at no cost, using NumberFly, a free online application:*http://www.interventioncentral.org/tools/early-math-fluency-generator* This program generates printable student and examiner assessment sheets for CBM Quantity Discrimination, Missing

Number, and Number Identification. From this site, the user can also download guidelines for administering and scoring these Early Math Fluency measures.

How To: Assess Mastery of Math Facts With CBM: Computation Fluency

Computation Fluency measures a student's accuracy and speed in completing 'math facts' using the basic number operations of addition, subtraction, multiplication, and division. Computation fluency in the elementary grades is a strong predictor of later success in higher-level math coursework (Gersten, Jordan, & Flojo, 2005).

For students to attain 'computational fluency', however, they must be both accurate and speedy in solving basic math facts--ideally through automatic recall (VanDerHeyden & Burns, 2008). In an influential report, the National Mathematics Advisory Panel (2008) stressed the need for students to become proficient in math facts, calling on schools to make it a priority to "develop automatic recall of addition and related subtraction facts, and of multiplication and related division facts." (p. xix).

The Common Core Standards also recognize the importance of computation fluency. For example, a 4th-grade math standard in Number and Operations in Base Ten (CCSM.4.NBT.4) states that the student will "fluently add and subtract multi-digit whole numbers using the standard algorithm" (National Governors Association Center for Best Practices et al., 2010; p. 29). However, the challenge for teachers is to define specifically what level of performance is required to identify a student as fluent in compuation.

CBM-Computation Fluency is a brief, timed assessment that can indicate to teachers whether a student is developing computation fluency and is thus on track to master grade-appropriate math facts (basic computation problems). This assessment can be administered to an individual student or to larger groups. The student is given a worksheet containing math facts and is given 2 minutes to answer as many problems as possible. The worksheet is then collected and scored, with the student receiving credit for each correct digit in his or her answers. Teachers can then compare any student's performance to research norms to determine whether that student is at risk because of delayed computational skills (Burns, VanDerHeyden, & Jiban, 2006).

Computation Fluency Measures: How to Access Resources. Teachers who would like to screen their students in grades 1 through 6 for possible delays in computation skills can obtain these free Computation Fluency assessment resources: (1) materials for assessment, (2) guidelines for administration and scoring, and (3) research-based norms.

- *Materials for assessment*. Schools can customize their own CBM Computation Fluency assessment materials at no cost, using the Math Worksheet Generator, a free online application: *http://www.interventioncentral.org/teacher-resources/math-work-sheet-generator*

  This program generates printable student and examiner assessment sheets for CBM Computation Fluency.

- *Guidelines for administration and scoring.* Instructions for preparing, administering, and scoring CBM-Computation Fluency assessments appear later in this document:

- *Research-based norms.* A table, *Curriculum-Based Measurement: Computation Fluency Norms* is included in this document. The table contains fluency benchmarks for grades 1-6, drawn from several research studies (e.g., Burns, VanDerHeyden, & Jiban, 2006).

References

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Curriculum-Based Measurement-Computation Fluency: Guidelines for Use

CBM-Computation Fluency: Description

CBM-Computation Fluency measures a student's accuracy and speed in completing 'math facts' using the basic number operations of addition, subtraction, multiplication, and division. CBM-Computation Fluency probes are 2-minute assessments of basic math facts that are scored for number of 'correct digits'.

There are 2 types of CBM math probes, single-skill worksheets (those containing like problems) and multiple-skill worksheets (those containing a mix of problems requiring different math operations). Single-skill probes give instructors good information about students' mastery of particular problem-types, while multiple-skill probes allow the teacher to test children's math competencies on a range of computational objectives during a single CBM session.

Both types of math probes can be administered either individually or to groups of students. The examiner hands the worksheet(s) out to those students selected for assessment. Next, the examiner reads aloud the directions for the worksheet. Then the signal is given to start, and students proceed to complete as many items as possible within 2 minutes. The examiner collects the worksheets at the end of the assessment for scoring.

Figure 1: A Sampling of Math Computational Goals for Addition, Subtraction, Multiplication, and Division (from Wright, 2002).

Addition
Two 1-digit numbers: sums to 10
Two 3-digit numbers: no regrouping
1- to 2-digit number plus 1- to 2-digit number: regrouping

Subtraction
Two 1-digit numbers: 0 to 9
2-digit number from a 2-digit number: no regrouping
2-digit number from a 2-digit number: regrouping

Multiplication
Multiplication facts: 0 to 9
2-digit number times 1-digit number: no regrouping
3-digit number times 1-digit number: regrouping

Division
Division facts: 0 to 9
2-digit number divided by 1-digit number: no remainder
2-digit number divided by 1-digit number: remainder

Wright, J. (2002) *Curriculum-Based Assessment Math Computation Probe Generator: Multiple-Skill Worksheets in Mixed Skills*. Retrieved from *http://www.interventioncentral.org/teacher-resources/math-work-sheet-generator*

CBM-Computation Fluency: Materials

The following materials are needed to administer CBM-Computation Fluency:

- Student and examiner copies of CBM Computation Fluency Probes
- Stopwatch
- Pencils for students

CBM-Computation Fluency: Preparation

After computational objectives have been selected, the instructor is ready to prepare math probes. The teacher may want to create single-skills probes, multiple-skill probes, or both types of CBM math worksheets. The teacher will probably want to consult the Common Core State Standards for Mathematics or district math curriculum when selecting the kinds of problems to include in the single- or multiple-skill probe.

Creating the single-skill math probe. As the first step in putting together a single-skill math probe, the teacher will select one computational objective as a guide. The worksheet, then, will consist of problems randomly constructed that conform to the computational objective chosen.

For example, the instructor may select any of the computational objectives in Figure 1 as the basis for a math probe. The teacher would then construct a series of problems that match the computational goal, as in Figure 2. In general, single-skill math probes should contain between 80 and 200 problems, and worksheets should have items on both the front and back of the page. Adequate space should also be left for the student to show his or her work, especially with more complex problems such as long division.

Figure 2: Example of a single-skill math probe: Three to five 3- and 4-digit numbers: no regrouping

```
    105   |      2031   |       111   |       634   |
+   600   |   +   531   |   +   717   |   + 8240    |
+   293   |   + 2322    |   +   260   |   +   203   |
```

Creating the Multiple-skill Math Probe. To assemble a multiple-skill math probe, the instructor will first select the range of math operations and of problem-types that will make up the probe. Once the computational objectives have been

Figure 3: Example of a multiple-skill math probe:

- *Division: 3-digit number divided by 1-digit number: no remainder*
- *Subtraction: 2-digit number from a 2-digit number: regrouping*
- *Multiplication" 3-digit number times 1-digit number: no regrouping*
- *Division: Two 3-digit numbers: no regrouping*

```
          |    20   |    113   |      106   |
  9/431   |   -18   |   x  2   |   +  172   |
          |         |          |   +  200   |
          |         |          |   +  600   |
```

chosen, the teacher can make up a worksheet of mixed math facts conforming to those objectives. Using our earlier example, the teacher who wishes to estimate the proficiency of his 4th-grade math group may decide to create a multiple-skills CBM probe. He could choose to sample only those problem-types that his students have either mastered or are presently being taught. Figure 3 shows four computation skills with matching sample problems that might appear on a worksheet of mixed math facts.

NOTE: Schools can customize their own CBM Computation Fluency assessment materials at no cost, using the Math Worksheet Generator, a free online application:
http://www.interventioncentral.org/teacher-resources/math-work-sheet-generator

CBM-Computation Fluency: Directions for Administration

1. The examiner distributes copies of math probes to all the students in the group, face down. (Note: These probes may also be administered individually). The examiner says to the students: "The sheets on your desk are math facts."
2. If the students are to complete a single-skill probe, the examiner says: "All the problems are [addition or subtraction or multiplication or division] facts."

If the students are to complete a multiple-skill probe, the examiner then says: "There are several types of problems on the sheet. Some are addition, some are subtraction, some are multiplication, and some are division [as appropriate]. Look at each problem carefully before you answer it."

3. The examiner then says: "When I say 'begin', turn the worksheet over and begin answering the problems. Start on the first problem on the left on the top row [point]. Work across and then go to the next row. If you can't answer a problem, make an 'X' on it and go to the next one. If you finish one side, go to the back. Are there any questions? ".
4. The examiner says 'Start' and starts the stopwatch. While the students are completing worksheets, the examiner and any other adults assisting in the assessment circulate around the room to ensure that students are working on the correct sheet and that they are completing problems in the correct order (rather than picking out only the easy items)..
5. After 2 minutes have passed, the examiner says, "Stop" and collects the CBM computation probes for scoring.
6. *Initial Assessment:* If the examiner is assessing the student for the first time, the examiner administers a total of 3 computation probes during the session using the above procedures and takes the median (middle) score as the best estimate of the student's computation fluency.
   Progress-Monitoring: If the examiner is monitoring student growth in computation (and has previously collected CBM-Computation Fluency data), only one computation probe is given in the session.

CBM-Computation Fluency: Directions for Practice

If the student is not yet familiar with CBM-Computation Fluency probes, the teacher can administer one or more practice computation probes (using the administration guidelines above) and provide coaching and feedback as needed until assured that the student fully understands the assessment.

CBM-Computation Fluency: Scoring Guidelines

Traditional approaches to computational assessment usually give credit for the total number of correct answers appearing on a worksheet. If the answer to a problem is found to contain one or more incorrect digits, that problem is marked wrong and receives no credit. In contrast to this all-or-nothing marking system, CBM assigns credit to each individual correct digit appearing in the solution to a math fact.

On the face of it, a math scoring system that awards points according to the number of correct digits may appear unusual, but this alternative approach is grounded in good academic-assessment research and practice. By separately scoring each digit in the answer of a computation problem, the instructor is better able to recognize and to give credit for a student's partial math competencies. Scoring computation problems by the digit rather than as a single answer also allows for a more minute analysis of a child's number skills.

Imagine, for instance, that a student was given a CBM math probe consisting of addition problems, sums less than or equal to 19 (incorrect digits appear in boldface and italics):

Figure 4: Example of completed problems from a single-skill math probe

105	2031	111	634
+ 600	+ 531	+ 717	+ 8240
+ 293	+ 2322	+ 260	+ 203
9***8***8	4884	108***7***	9***0***77

If the answers in Figure 4 were scored as either correct or wrong, the child would receive a score of 1 correct answer out of 4 possible answers (25 percent). However, when each individual digit is scored, it becomes clear that the student actually correctly computed 12 of 15 possible digits (80 percent). Thus, the CBM procedure of assigning credit to each correct digit demonstrates itself to be quite sensitive to a student's emerging, partial competencies in math computation.

The following scoring rules will aid the instructor in marking single- and multiple-skill math probes:

- Individual correct digits are counted as correct.
  Reversed or rotated digits are not counted as errors unless their change in position makes them appear to be another digit (e.g., 9 and 6).

- Incorrect digits are counted as errors.
  Digits that appear in the wrong place value, even if otherwise correct, are scored as errors.

  Example

  ```
    97
    x9
  8730
  ```

  "873" is the correct answer to this problem, but no credit can be given since the addition of the 0 pushes the other digits out of their proper place-value positions.

- The student is given credit for "place-holder" numerals that are included simply to correctly align the problem. As long as the student includes the correct space, credit is given whether or not a "0" has actually been inserted.

  Example

  ```
    55
  x 82
   110
  4400
  4510
  ```

  Since the student correctly placed 0 in the "place-holder" position, it is given credit as a correct digit. Credit would also have been given if the space were reserved but no 0 had been inserted.

- In more complex problems such as advanced multiplication, the student is given credit for all correct numbers that appear below the line.

  Example

  ```
    33
  x 28
   264
   660
   924
  ```

  Credit is given for all work below the line. In this example, the student earns credit for 9 correct digits.

- Credit is not given for any numbers appearing above the line (e.g., numbers marked at the top of number columns to signify regrouping).

  Example

  ```
     1
    46
  + 39
    85
  ```

  Credit is given for the 2 digits below the line. However, the carried "1" above the line does not receive credit.

Curriculum-Based Measurement: Computation Fluency Norms

(Burns, VanDerHeyden, & Jiban, 2006; Deno & Mirkin, 1977; Fuchs & Fuchs, 1993; Fuchs & Fuchs, n.d.)*

CBM-Computation Fluency measures a student's accuracy and speed in completing 'math facts' using the basic number operations of addition, subtraction, multiplication, and division. Computation fluency in the elementary grades is a strong predictor of later success in higher-level math coursework (Gersten, Jordan, & Flojo, 2005). CBM-Computation Fluency probes are 2-minute assessments of basic math facts that are scored for number of 'correct digits'.

Grade	End of Year Benchmark: Correct Digits per 2 Mins (Fuchs & Fuchs, n.d.)	Weekly Growth: 'Realistic' (Fuchs & Fuchs, 1993)	Weekly Growth: 'Ambitious' (Fuchs & Fuchs, 1993)
1	20	0.3	0.5

Grade	Performance Level	Correct Digits per 2 Mins (Burns, VanDerHeyden, & Jiban, 2006)	Weekly Growth: 'Realistic' (Fuchs & Fuchs, 1993)	Weekly Growth: 'Ambitious' (Fuchs & Fuchs, 1993)
2	Mastery	More than 31	0.3	0.5
	Instructional	14-31		
	Frustration	Less than 14		
3	Mastery	More than 31	0.3	0.5
	Instructional	14-31		
	Frustration	Less than 14		
4	Mastery	More than 49	0.75	1.2
	Instructional	24-49		
	Frustration	Less than 24		
5	Mastery	More than 49	0.75	1.2
	Instructional	24-49		
	Frustration	Less than 24		

Grade	Performance Level	Correct Digits per 2 Mins (Deno & Mirkin, 1977)	Weekly Growth: 'Realistic' (Fuchs & Fuchs, 1993)	Weekly Growth: 'Ambitious' (Fuchs & Fuchs, 1993)
6	Mastery	More than 79	0.45	1.0
	Instructional	40-79		
	Frustration	Less than 40		

References:

- Burns, M. K., VanDerHeyden, A. M., & Jiban, C. L. (2006). Assessing the instructional level for mathematics: A comparison of methods. *School Psychology Review, 35*, 401-418.
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- Fuchs, L. S., & Fuchs, D. (1993). Formative evaluation of academic progress: How much growth can we expect? *School Psychology Review, 22*, 27-49.
- Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38*, 293-304.

*Reported Characteristics of Student Sample(s) Used to Compile These Norms:

- Burns, VanDerHeyden, & Jiban, 2006: *Number of Students Assessed:* 434 students across grades 2-5/*Geographical Location:* Southwest: Sample drawn from 1 elementary school/ *Socioeconomic Status:* 15% rate of Free & Reduced Lunch/ *Ethnicity of Sample:* 74% Caucasian-non-Hispanic; 17% Hispanic or Latino; 6% African-American; 3% Asian-American; 1% Native American/*Limited English Proficiency in Sample:* 2% of students.
- Deno & Mirkin, 1977: *Number of Students Assessed:* Not reported/*Geographical Location:* Sample drawn from 1 elementary school; location not reported/ *Socioeconomic Status:* Not reported/ *Ethnicity of Sample:* Not reported/*Limited English Proficiency in Sample:* Not reported.
- Fuchs & Fuchs, n.d.: *Number of Students Assessed:* Not reported/*Geographical Location:* Not reported/ *Socioeconomic Status:* Not reported/ *Ethnicity of Sample:* Not reported/*Limited English Proficiency in Sample:* Not reported.
- Fuchs & Fuchs, 1993: *Number of Students Assessed:* Year 1: 177 students in grades 1-6; Year 2:1208 students across grades 1-6/*Geographical Location:* Upper Midwest: Sample drawn from 5 elementary schools/ *Socioeconomic Status:* 33%-55% rate of Free & Reduced Lunch across participating schools/ *Ethnicity of Sample:* Not reported/*Limited English Proficiency in Sample:* Not reported.

Where to Find Materials: Schools can create their own CBM Computation Fluency assessment materials at no cost, using the Math Worksheet Generator, a free online application:
http://www.interventioncentral.org/teacher-resources/math-work-sheet-generator

This program generates printable student and examiner assessment sheets for CBM Computation Fluency.

Limitations of These Research Norms: Norms generated from small-scale research studies--like those used here--provide estimates of student academic performance based on a sampling from only one or two points in time, rather than a more comprehensive sampling across separate fall, winter, and spring screenings. These norms also have been compiled from a relatively small student sample that is not fully representative of a diverse 'national' population. Nonetheless, norms such as these are often the best information that is publically available for basic academic skills and therefore do have a definite place in classroom instruction decision-making.

These norms can be useful in general education for setting student performance outcome goals for core instruction and/or any level of academic intervention. Similarly, these norms can be used to set performance goals for students with special needs. In both cases, however, single-sample norms would be used only if more comprehensive fall/winter/spring academic performance norms are not available.