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The Science of Math and Class-Wide Math Intervention

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In education, there is a history of pitting philosophy against science. For example, in reading instruction, the so-called reading wars dominated decades of practice and reflected polarized groups, one group embracing science and research as the way to instruct reading and another group prioritizing philosophy and theory. A seismic shift in education was apparent by 2001, at which time policies began to coalesce around a position that learning is measurable and that stewards of resources devoted to learning should allocate those resources to practices that have been shown work in research. More recently, the science of reading emerged as a largely advocacy driven movement organized by parents of children who had not successfully learned to read (or were not successfully learning to read) during their primary-grade years. These parents were dismayed to find a substantial evidence base about how reading can best be taught and then to discover that many of the educators they trusted at their students' schools were either unaware of the scientific bases of effective reading instruction or were simply opposed to its use. Thus, the science of reading movement was launched.

In mathematics, a similar divide exists between evidence-based practice and philosophy-based practice. Philosophy-based practices are very prevalent in math and are not simply benignly ineffective tactics: At best, they compete with and prevent the use of evidence-based tactics in math instruction and at worst may directly harm learning (VanDerHeyden & Codding, 2020). Much like the reading wars, there is a divide between math educators who look to research to inform practices and those who look to popular ideas or tactics promoted by thought leaders. While the adults are consumed with debate, U.S. students' math performance is shockingly weak, with pronounced opportunity gaps. The science of math (www.thescienceofmath.com) is a movement of like-minded researchers, caregivers, educators, and educator leaders who believe that all students deserve the opportunity for mathematical proficiency and all the benefits that proficiency conveys in their present and future lives. The science of math is a movement that focuses on using objective evidence about how students learn math in order to make educational decisions and to inform policy and practice. We believe that school psychologists, as data-based decision-making consultants and MTSS experts in schools, are critical allies in promoting research-based practices in mathematics. This article is the first of a series of articles appearing in *Communiqué* about how school psychologists can adopt and promote evidence-based practices in math assessment and instruction. Future articles will address topics including equity in mathematics, curriculum-based measurement updates in mathematics, math anxiety and timed tasks, how to build intensified individualized math interventions, and how to use math MTSS data for program evaluation and eligibility determination.

What Is Class-Wide Intervention?

A benefit of instituting universal screening in mathematics is that educators can essentially take a "temperature check" to assess skill proficiency for individuals and groups. Educators can determine if only a few students in a class or the entire class are performing lower than expected for grade level. Administrators can look at performance at the student, class, grade, or even school level. Classes of students for whom the average (median) performance falls at or below the 25th percentile according to the nationally or locally normed screening tool or below some other established benchmark for interpretation would benefit from class-wide intervention approaches targeting critical foundational skills that are missing for the majority of students. If universal screening data reveal that a large proportion of the students in the school are performing below expectations, class-wide intervention is also useful to supplement core instruction.

The emphasis of class-wide intervention is to improve the average performance level of students in the class. Students who do not respond to supplemental class-wide intervention would benefit from intensified instruction (e.g., Tier 2 or 3). Often, class-wide interventions are designed to be brief depending on the scope of content the intervention will cover. Universal screening data or additional assessment tools, such as curriculum-based assessment, are used to identify the skills and concepts that will serve as the focus of the class-wide intervention. Class-wide interventions improve core foundational math skills by enhancing the number of opportunities to practice math skills as well as by increasing the amount and/or type of feedback provided to students. Class-wide interventions can be built into brief spurts that take advantage of naturally occurring downtime (e.g., Schutte et al., 2015) or are more structured into standard core instructional routines (e.g., VanDerHeyden et al., 2012).

Class-wide interventions might target one skill or concept or many skills and concepts and address the same target skill/concept(s) universally or provide different content for students to practice on during the intervention period. Class-wide interventions have used tactics like cover–copy–compare, explicit timing, or taped problems with goal setting, group contingencies, and/or specific reinforcement (e.g., Kleinert et al., 2018, Poncy et al., 2012; Poncy & Skinner, 2011), and detect–practice–repair formats where students are asked to identify and repair errors in already worked problems (e.g., Poncy et al., 2013). All class-wide interventions employ reciprocal peer tutoring during which students take turns serving in the tutor and tutee roles.

Origins of Class-Wide Intervention

Class-wide intervention was pioneered first by Greenwood (1991), who called the technique "class-wide peer tutoring." In this seminal work, Greenwood theorized that increasing the dosage of opportunities to respond experienced by students would improve student engagement and learning. He devised an experiment to evaluate the effect of class-wide peer tutoring over 2 years of instruction and found that class-wide peer tutoring did, indeed, have strong positive effects on student engagement and academic outcomes. Greenwood (1991) followed three groups of students from first to third grade: The experimental group consisted of students who were identified as low-performing and from low-SES backgrounds, an equivalent control group consisted of students considered to be low-performing and from low-SES backgrounds, and a comparison group consisted of peers who were not considered at risk and were from average- to high-SES backgrounds. The study followed these students into grade 3. The experimental group was provided with class-wide peer tutoring. The control and comparison groups were provided with business-as-usual instruction. By grade 3, the group that was provided with class-wide peer tutoring outperformed the equivalent control group in gains on a standardized achievement measure and performed comparably to the original not-at-risk group. Students who received class-wide peer tutoring also demonstrated greater engagement during instruction and more instructional time than did the control group, which was the hypothesized mechanism of action toward improving achievement.

School psychologists are likely familiar with subsequent efforts to build and evaluate class-wide intervention. For example, Fuchs and colleagues developed a model that they called "peer assisted learning strategies" or "PALS" and subsequently conducted a series of experiments in reading and math over 2 decades, finding positive effects on learning for students of varying ability levels (Fuchs et al., 2001). The PALS model was an important step forward because it provided a hierarchy of skills to be targeted and developed student materials and training materials to equip teachers to use PALS in general education classrooms.

Class-Wide Intervention in MTSS

VanDerHeyden and colleagues developed class-wide intervention as part of a comprehensive model of RTI and MTSS in the early 2000s and extended class-wide intervention from being only a method to boost academic learning gains to one that informs and improves screening decisions. Assessment of student performance alone will always carry bias when access to highly effective instruction is unstable. Because access to highly effective instruction is unstable across schools and classrooms, static screenings can result in inequitable (i.e., overidentification) identification of marginalized or minoritized groups. However, these problems can be avoided by using class-wide intervention responsiveness as the basis for advancing to more intensive instruction. In effect, class-wide intervention reduces bias and increases decision accuracy (VanDerHeyden, 2013; VanDerHeyden et al., 2020). As a result of evidence demonstrating that class-wide intervention can benefit student learning of all ability levels and at the same time provide a stronger basis for screening decisions when risk is high, class-wide intervention is now formally situated in MTSS as Tier 1.5 (Kovaleski et al., in press).

Class-wide math intervention, as developed and evaluated by VanDerHeyden, is a standard-protocol, fluency building intervention that uses the class-wide peer tutoring format to build fluency (accuracy plus speed, Binder, 1996) in essential academic skills. At least two tools exist that are designed to make this process teacher friendly (e.g., PALS and SpringMath). SpringMath (Education Research & Consulting, Inc., 2013) will be used as an illustration of some of the concepts presented in this article (full disclosure: Dr. VanDerHeyden is the author of SpringMath).

The active ingredients of class-wide math intervention include the following: Students work in pairs and take turns practicing the skill. In a standard class-wide tutoring session, the "worker" student works for 3 minutes, thinking aloud while solving each problem. The "helper" student follows along, detecting errors, and helping when the worker is stuck. Then the students switch roles. Finally, students complete a timed interval of performance and try to beat their last-best scores. When the class median reaches mastery, the entire class advances to the next skill in the skill sequence for their grade level. Implementers can follow the number of skills mastered in classes at the whole-skill level to identify classes that might require in-class coaching to improve use and results. Students who fall behind relative to their classmates receiving the same intervention with the same degree of fidelity should be recommended for brief diagnostic assessment and intensified instruction at Tiers 2 or 3 of MTSS (Kovaleski et al., in press). To access a protocol for class-wide math intervention, see https://www.sourcewelltech.org/sites/tech/files/2020-12-31/SpringMath_SampleClassIntervention_0819.pdf (PDF).

- Model of correct responding provided by the teacher

- Partner practice with reciprocal roles with teacher support to verify productive practice
- Use of instructional-level task materials
- High dosage of opportunities to respond
- Personal goal setting and monitoring
- Error correction with peers
- Group contingency with class-wide reward system

Class-wide intervention requires 15–20 minutes each day and produces rapid gains on proximal measures. Cost effectiveness analyses have demonstrated very low cost to academic gain values (e.g., incremental cost effectiveness ratios; Barrett & VanDerHeyden, 2020). Research data conducted on class-wide math intervention have replicated moderate to strong effects on academic performance for all students and reduction of risk overall, causing smaller numbers of children to require Tier 2 or 3 intervention (VanDerHeyden & Codding, 2015; VanDerHeyden et al., 2012; VanDerHeyden et al., 2007).

Because class-wide math intervention is a fluency building intervention by design, one pitfall to avoid is conducting class-wide intervention when students have not yet acquired the skill. This pitfall can easily be detected after the first day of intervention by scanning the students' work to verify that most students are responding in the instructional range of performance. Some commercial tools will automatically check to make sure the class median score falls within an instructional range and offer an acquisition lesson to teach requisite skills if the median is below an instructional range. But if you are not using a commercial tool, you can simply scan the work on day one and if the scores are very low, provide a lesson that emphasizes acquisition instructional tactics like modeling and immediate corrective feedback to establish correct understanding of the skill before continuing with class-wide intervention.

Because class-wide interventions develop students' fluency with previously learned skills, and because math skills progress in complexity, each grade level works on a unique sequence of static skill. Each grade-level sequence begins with below-grade level skills to increase the probability that they have been taught to students. Success in the early skills ensures success in the later skills (the sequences build). Such sequences are very logical and can be developed locally in concert with teacher input if your system is not using a commercial tool with already developed sequences. As an example, the skill sequence used for Grade 6 in SpringMath is provided in Table 1. Note, the sequence begins with below-grade level skills. Teachers begin with the first skill and if the median score is at mastery, then the entire class moves immediately to the next skill until they find their intervention sequence starting point. Once they find their starting point, students should only be moved weekly and only when the median reaches mastery.

Table 1. Grade 6 Class-Wide Intervention Skill Sequence

■ 2-Digit Subtraction With & Without Regrouping
■ Multi-Digit Multiplication With & Without Regrouping
■ Multi-Digit Division With & Without Remainders
■ Order of Operations
■ Find Least Common Denominator

- Simplify Fractions (A)
- Simplify Fractions (B)
- Simplify Fractions (C)
- Add & Subtract Fractions With Unlike Denominators
- Add & Subtract Mixed Numbers With Like Denominators and Regrouping
- Convert Improper Fractions to Mixed Numbers
- Multiply & Divide Proper and Improper Fractions
- Convert Mixed Numbers to Improper Fractions
- Multiply & Divide Mixed Numbers
- Mixed Fraction Operations
- Distributive Property of Expression
- Collect Like Terms
- Substitute Whole Number to Solve Equations
- Find Percent of a Whole Number
- Add & Subtract Decimals to the Hundredths
- Multiply & Divide Decimals
- Multiply 2-Digit by 2-Digit With Decimals
- Quantity Comparison With Integers
- Graph in a Coordinate Plane Skill

Sequence used in SpringMath (www.springmath.com). Reprinted by permission of author.

What Effects Can I Expect?

Class-wide math intervention has a rich history of research conducted in school psychology. For example, Skinner et al. (1989) shared findings demonstrating increased multiplication performance. Almost a decade later, Allsopp (1997) shared results from what he referred to as a class-wide peer tutoring intervention to teach algebra concepts to students in Grade 8. Poncy and colleagues (e.g., 2006, 2013) and Codding et al. (2011) evaluated early numeracy performance for students in kindergarten. Each of these studies focused on a specific instructional tactic. Evaluating the collective effects of class-wide math interventions for skill fluency, Burns et al. (2010) and Hughes et al. (in preparation) determined that class-wide interventions have medium to high effects on students' performance, suggesting positive return on academic investment (Barrett & VanDerHeyden, 2020).

At the elementary level, evidence suggests that a variety of class-wide interventions that address arithmetic skills and concepts or word-problem solving benefit all students, including and especially those at greater risk for mathematics failure (e.g., Codding et al., 2011; Fuchs et al., 2009; Fuchs et al., 2014; VanDerHeyden et al., 2012). Not only have students' immediate outcomes improved but skill retention and generalization have also been observed, with high acceptability ratings from teachers and students (e.g., Codding et al., 2009; Grafman & Cates, 2010; Poncy et al., 2013), and closures of opportunity gaps (VanDerHeyden & Codding, 2015).

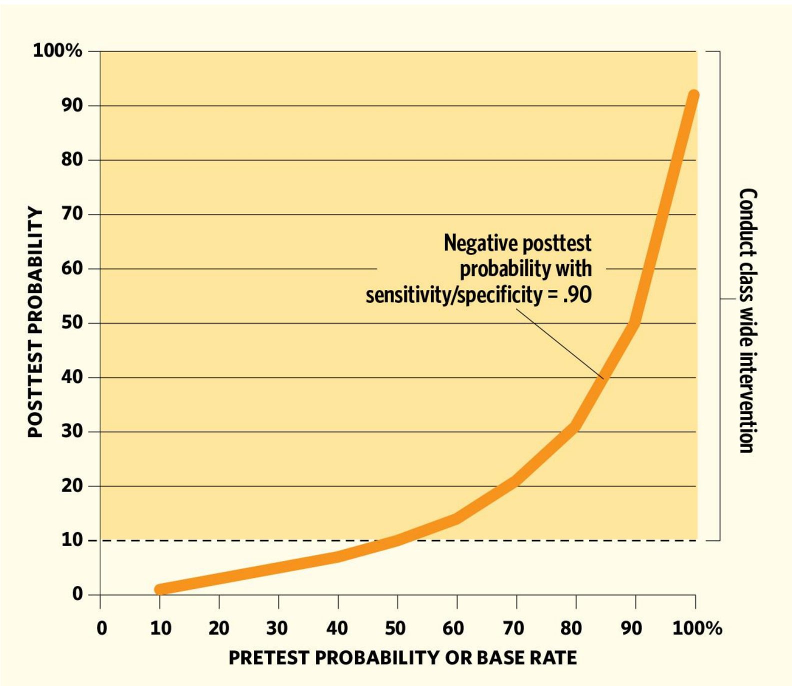
Gains on proximal and distal measures. Benefits of class-wide interventions have been documented on proximal and distal measures (e.g., Fuchs, et al., 2001; VanDerHeyden et al., 2012; VanDerHeyden & Codding, 2015). Proximal measures evaluate the effects of the intervention on closely related skills. It may be easier to detect changes in proximal measures because they closely align directly with the skills being taught. As a rule of thumb when implementing intervention, implementers can use proximal measures to guide implementation, and gains on the proximal measures are necessary to obtain gains on the distal measures. Distal measures often assess a broader range of skills and provide additional support to determine if the skills are being generalized, which is especially important for class-wide interventions. Year-end test performances are generally important distal measures for systems to pay attention to. Gains on year-end measures have been demonstrated via class-wide math intervention (Greenwood, 1991; VanDerHeyden et al., 2012).

Closure of opportunity gaps. Opportunity gaps occur where performances are weaker among students who share some characteristic, like race, gender, SES, or disability status. For example, when performance differs on average between students who receive free or reduced-price lunch versus students who do not receive free or reduced-price lunch, that may have been previously referred to as an equity or performance gap. However, given adequate resources, those gaps can be closed, so they are now referred to as “opportunity gaps” (Barrett & Guttman-Lapin, 2020). Class-wide math intervention has specifically been shown to close opportunity gaps. In one randomized controlled trial (VanDerHeyden & Codding, 2015), before intervention White students outperformed Black students in both the treatment and the control groups. After class-wide intervention, White students no longer outperformed Black students in the treatment group. In the control group, which did not receive class-wide intervention, the gap remained with White students continuing to outperform Black students. This replicated earlier work conducted by VanDerHeyden & Witt (2005) demonstrating that screening alone produced inequitable identification (risk was disproportionate), whereas only 5 to 7 intervention sessions caused risk to be proportionate. Thus, class-wide intervention is a powerful mechanism to promote equity and close opportunity gaps in schools.

Practical Advice for Screening and Intervention After School Closures

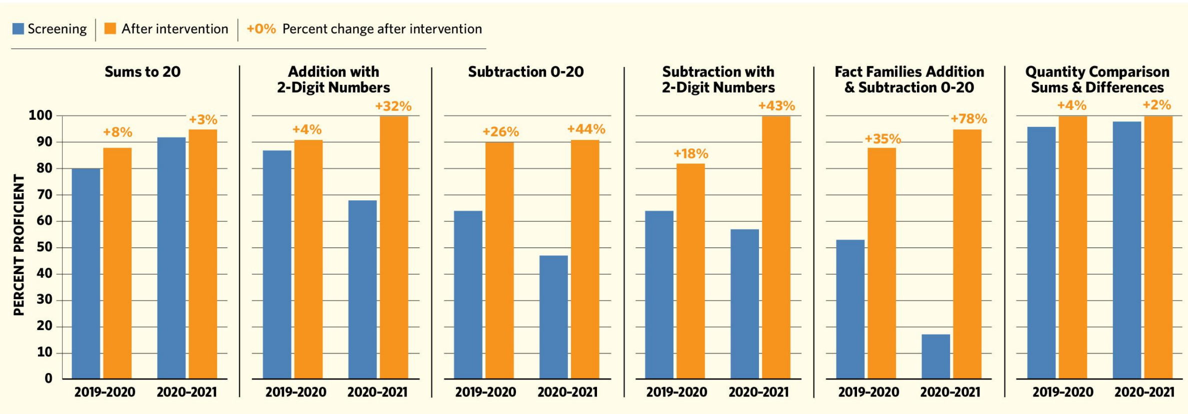
Given the likelihood that many students will score lower following extended school closures and remote instruction due to the COVID pandemic, some school psychologists have wondered if assessment should simply be delayed or avoided. In our view, it would be a bad idea to simply avoid assessment. On the other hand, it makes little sense to overcollect assessment data given that learning loss is highly probable. In fact, presuming students are at risk for math difficulties may be less error-prone than screening children and applying cut-off scores to rule students out of intervention groups. In other words, risk for learning loss is high enough in most places that an assessment concluding otherwise may be more likely to be wrong than right (see Figure 1). The negative posttest probability (y-axis) is the probability that a student who passes the screening will fail the year-end test. Its relationship to the amount of risk in an environment (shown on the x-axis) is lawful and climbs rapidly in contexts where risk is high. One can see that if you are trying to use academic screening to determine who is at risk in a context where 50% of students are nonproficient, 10% of students who pass the screening will go on to fail the year-end test. This reality cannot be avoided by choosing a more accurate screener and in fact, in Figure 1, we have modeled negative posttest probability for a very accurate screening (90% sensitivity, 90% specificity). The pattern is the same when classification accuracies are weaker or stronger, except the climb in negative posttest probability is even more rapid. You cannot avoid this problem by administering more screening measures at the same time. The only way to reduce negative posttest probability into a tolerable range for decision making is to attempt to reduce real risk in the setting—and that is the function of class-wide math intervention. Additionally, class-wide math intervention responsiveness provides a richer data source from which to identify individual student risk. It causes the scores to be more normally distributed and provides trend information in addition to level of performance.

Figure 1. Probability That a Student Who Passes the Screening Will Actually Fail the Criterion



Instead of avoiding assessment, we suggest conducting a brief screening to establish a new baseline of proficiency in each class, installing class-wide intervention into that setting right away (without waiting, without collecting additional assessment data), and then using the class-wide intervention data to more accurately determine which students need intensive, individualized support. Where risk is high, it will be helpful to use sensitive, direct measures of essential skills such as would be used with mastery measurement in curriculum-based measurement. This streamlined approach allows you to repair learning loss and notice the results of the gaps closing across subsequent screenings. For example, in Figure 2, a second grade's screening results are shown for winter screening across 2 consecutive years, in the year before extended school closures and in the year of extended closures and hybridized instruction. Because the school was able to conduct class-wide intervention beginning Winter 2021 with strong implementation, we see that even though the winter screening scores were lower relative to the preceding year, the learning gains were greater and students reached the same level of proficiency as in the prior year. These data provide an example of the successful reparation of learning losses in math at a grade level in a district.

Figure 2. Gains on Screening Measures in Grade 2 in the Years Before and After COVID Closures



Class-wide intervention is a highly efficient tactic to bring about learning gains in classrooms. Research evidence supports the use of class-wide intervention to improve learning overall, to close opportunity gaps in systems (i.e., promote equity), and to make more accurate decisions about which students need intensified instruction (e.g., Tiers 2 or 3) and potentially an eligibility evaluation. Because of these benefits documented by independent researchers and across multiple models, class-wide intervention is now formally situated in MTSS as Tier 1.5. School psychologists should have class-wide intervention in their toolkit to promote mathematics success for all students. For additional information, readers can access: www.scienceofmath.com and https://www.nasponline.org/resources-and-publications/resources-and-podcasts/covid-19-resource-center/return-to-school/considerations-for-math-intervention-upon-the-return-to-school.

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