# Promoting Positive Math Outcomes

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## INTRODUCTION

The poor performance of U.S. students in the area of mathematics has been well documented throughout the last decade. International and national assessments of mathematics performance including the Trends in International Mathematics and Science Study (TIMSS), the Programme for International Student Assessment (PISA), and the National Assessment of Educational Progress (NAEP) all suggest the need for an overhaul of mathematics education. *What* we teach (math standards), *how* we teach (explicitly or indirectly) and *how we measure* student progress (continuously or annually) have emerged as important topics of interest to the education community at large as well as the general public.

The TIMSS is a comprehensive cross-country comparative study of mathematics and science. While the TIMSS data have been collected every 4 years since 1995, the 2007 data were not available at the time this chapter went to press. Therefore, our comments are based on the 2003 study. In 2003, 46 countries participated in TIMSS, at either the fourth- or eighth-grade level, or both. In the 2003 study, only 7% of U.S. eighth-grade students scored at the *advanced* level compared to about one-third of the students from the highest performing (A+) countries (Mullis, Martin, Gonzales, & Chrostowski, 2004). Although the mathematics performance of U. S. eighth graders improved between 1995 and 2003, most of that progress occurred between 1995 and 1999.

Another international assessment, PISA, provided even less positive results than TIMSS (Organisation for Economic Co-operation and Development, 2004). PISA is a standardized assessment developed jointly by 41 participating countries. The assessment includes areas of mathematics that 15-year-olds need for life skills and as a basis for further study of mathematics. In the 2000 assessment, the performance of U.S. students in overall mathematics literacy and problem solving was lower than the average performance of students for most countries. As in the 2000 PISA, the 2003 PISA assessment showed that about two-thirds of the students in participating countries outperformed the U. S. students. In 2003, more U. S. students scored at or below the lowest level of proficiency in problem solving than the international average.

Although the math portion of the 2006 PISA was less in depth than the 2003 assessment (Organisation for Economic Co-operation and Development, 2007), results were similar with American students performing significantly below the international average, just behind Azerbaijan and the Russian Federation. Of additional concern is that the United States has a below average proportion of high-performing students as compared to the other participating countries.

The math performance of U. S. students as measured by the National Assessment of Educational Progress (NAEP) appears to be consistent with findings from the international studies. In 2003 data from the NAEP showed that only 29% of eighth-grade students scored at the *proficient* level (National Center for Educational Statistics, 2003). Thirty-two percent of the eighth graders taking the 2003 NAEP scored below *basic* level demonstrating only partial mastery of the prerequisite knowledge and skills that are fundamental for proficient work. For example, only 10% of eighth graders could demonstrate three ways to divide an L-shaped figure in order to determine its area.

Results of the 2007 NAEP for Grades 4 and 8 recently have been published (National Center for Educational Statistics, 2007). The findings suggest that both fourth- and eighth-graders are scoring higher than in earlier assessments with steady increases in scores since 1990. However, when disaggregated, the data show that the performance of students who are eligible for free and reduced lunch remains widely discrepant from the performance of those not eligible.

Approximately one-third of fourth graders (30.0%) who are eligible for free and reduced lunch performed below the *basic* level compared to only 8.9% of those not eligible; close to half of all eighth graders eligible for free and reduced lunch performed below basic (45.4 %) compared to 18.6% of those not eligible. Regardless of the reported increases, the performance of students who may be considered most at risk for academic failure is clearly unacceptable by any standard.

***Performance of Students with Math Learning Disability (MLD)***

The poor math performance reports of general education students briefly summarized to this point suggest that the problems facing students with MLD may be even more daunting. Although the etiology of MLD is unknown at this time, and there is no known diagnostic tool for reliably identifying students with MLD, Geary (2004) has estimated that 5-8% of school-aged children have been identified as having a math learning disability. Available research in special education has documented that the performance of those students identified as having a math disability lags significantly behind the performance of their non-disabled peers but that the performance of these students is quite variable (Cawley, Parmar, Foley, Salmon, & Roy, 2001; Gersten, Jordan & Flojo, 2005; Harris, Miller, & Mercer, 1995; Miller, Butler, & Lee, 1998; Montague & Applegate, 2000). More specifically, students with MLD tend to struggle with fluent computational skills, including arithmetic fact retrieval that is believed to be associated with poor working memory and/or other associated deficits in cognition (Geary, 2004; Mabbott & Bisanz, 2008).

Addressing the needs of struggling students, whether they receive math instruction in general or special education is a particular focus of this chapter on promoting positive math outcomes.

***Current Reform Efforts in Mathematics Instruction***

The recent demand for mathematics reform and the corresponding math debates not surprisingly, are comparable to the reading reform efforts of the 1980's and 1990's. The debate in reading at these times centered on the relative merits of using (a) an *explicit phonics approach* versus (b) a more *implicit whole language approach* to teach beginning reading. In math, the debate centers on using *explicit strategy instruction* versus *guided discovery* to teach computation and problem solving. Although the research community continues to generate and investigate questions of both theoretical and practical importance, the impact of these debates on classroom instruction remains considerable. The design and implementation of state standards, state assessments, curriculum adoption frameworks, and subsequently the development of curricula for both academically successful and academically challenged students lie in the balance.

To resolve the reading debates between explicit phonics and implicit whole language, the National Reading Panel (NRP), was convened by Congress in 1997 and produced a research report called *Teaching Children to Read* (National Institute of Child Health and Human Development, 2000). Similarly, to resolve the explicit strategy versus implicit guided discovery debates in math, the National Mathematics Advisory Panel (NMP) was created in 2006 and charged to provide the Department of Education with advice on the use of scientifically based research in mathematics. In 2008, the NMP report, *Foundations for Success* was completed.

One striking difference between the reading and math reform efforts can be found in the volume of high quality research available for review in each area. While the reading research community has been actively conducting research for decades, a major theme running through the NMP report is the need for more math research. Despite this research literature volume difference, the NMP does make research-based recommendations throughout its report and we have included references to the panel's findings and recommendations in later sections.

## A PROBLEM SOLVING APPROACH TO MATH IMPROVEMENT

Reform initiatives like those in reading and math arise when a discrepancy between actual levels of student performance and expected levels of performance becomes apparent (Deno, 2002). Regardless of whether the discrepancy is found within general education (e.g., the poor performance of U. S. students compared to students from other countries), compensatory education (e.g., the performance gap between students eligible for free and reduced lunch and those not eligible) or special education (e.g., the underperformance of students with MLD compared with their non-disabled peers), addressing these performance discrepancies inevitably requires educators to engage in some form of problem solving.

Problem solving approaches to educational challenges are not new (Bransford & Stein, 1984, Deno & Mirkin, 1977). Fuchs and Deshler (2007) observed that currently the term "problem solving" is used in three distinct ways. First, the term is used to describe how general education teachers prepare to differentiate instruction for individual students within their classrooms. Second, the term is used to refer to the careful planning and preparation required to address the more serious academic and social-emotional challenges that students with disabilities face. Finally, the term is used to describe the schoolwide decision-making process that often guides building teams in their effort toward improving the academic performance of students most at risk for failure.

Response to intervention (rti), essentially a problem-solving approach, exemplifies all three uses of the term as outlined above. Response to intervention is predicated on the assumption that high quality instruction in the general education classroom (i.e., tier-1) can prevent significant academic failure for most students. Students who respond poorly to that instruction then become candidates for interventions and may be eligible for special education services (i.e., Tier 2). Research suggests that using this type of problem solving approach may not only reduce the prevalence of MLD but also improve the performance of students with MLD (Fuchs et al., 2005; Shapiro, Edwards, & Zigmond, 2005).

Collaboration among teachers and other school personnel (including school psychologists and principals) appears to be central to the implementation of most successful schoolwide problem solving approaches, including rti (Ephraim, 2008; Gersten, Chard, & Baker, 2000). However, even in schools where mutual accountability is inherent in the school culture, coordinating the efforts of all school personnel remains a challenge. Recent research suggests that the use of instructional coaches may be an effective and efficient way to organize and implement the activities associated with the type of problem solving necessary for improving student performance in math using multi-tier early intervening services (Gersten, Morvant & Brengelman, 1995; Knight, 2005).

Four main categories of literacy coaches based on the amount of time they spend on specific activities have been identified by Deussen, Coskie, Robinson, and Autio (2007). *Data-oriented* coaches spend most of their school time coordinating assessments and managing student performance data. *Student-oriented* coaches spend more of their time directly providing interventions to small groups of students. *Managerial* coaches are responsible for facilitating and planning team meetings and coordinating inservice activities. Finally, *teacher-oriented* coaches are the coaches who spend most of their time in individual classrooms or in small groups working directly with teachers.

In this chapter, we have conceptualized a problem solving approach in which the math coach plays a central role. Based on the activities described earlier, we have organized the primary responsibilities of the math coach into two major areas: (a) assessing for mathematics instruction and (b) math action planning. These areas are central features of problem solving approaches, including rti, that are grounded in data-based decision making (Deno, 2002; Fuchs & Deshler, 2007; Walker & Shinn, 2002). The coach-based approach we describe below extends most other approaches by more explicitly linking assessment to professional development activities.

## Assessing for Mathematics Instruction

In order to assist teachers in using relevant information for academic problem solving, we developed the Mathematics Problem Solving (MPS) Inventory. This inventory is divided into three distinct areas: (a) Assessment, (b) Curriculum and Instruction, and (c) Professional Development. While most problem-solving models include an analysis of student performance data, math coaches using this inventory also collect information about curriculum materials and organization, and professional development needs including inservice training and math coaching needs. Although the Inventory itself is too lengthy to be reproduced here, we have provided examples of the kinds of questions that appear in each of the three areas included on the Inventory (see Figure 1). The entire MPS Inventory is available from the authors upon request.

Insert Figure 1 about here

To help organize the information that is collected by the math coach, we have developed a corresponding MPS Summary Form (see Figure 2). Using data from the MPS Inventory, the math coach indicates on the MPS Summary Form those areas for which an action may be needed. This form helps the math coach consolidate a large amount of information so that it can be more easily shared with teachers and other school personnel.

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Insert Figure 2 about here

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## ***Assessment***

### ***Student Performance Measures***

In this section we briefly outline four different types of student performance measures included on the MPS Inventory to assist teachers and coaches as they make critical instructional decisions: Benchmark Assessment, Progress Monitoring, Program-specific Assessment, and Assessment of Content Coverage. The questions on the MPS Inventory guide the math coach to record information about the assessments given to students in each of the three tiers so that they can better determine whether more or different types of measures are needed to inform the action planning process.

***Benchmark Assessment.*** Benchmark measures are given to help determine the extent to which students are meeting grade-level expectations. This type of assessment provides data to help identify early those students who may need additional support (i.e., universal screening). For many school systems, benchmark assessments are administered three times a year, in the fall, winter, and spring. The beginning of the year assessment not only helps to identify which students are starting the year below expected levels but also provides teachers with a general sense of the instructional levels of the students in the class. The winter and spring assessments provide data on student progress toward end of the year goals and state standards. Schools currently using benchmark assessments for reading are increasingly aware of the benefits of this type of assessment and will find the application to math fairly easy.

Students performing slightly below expected levels on benchmark assessment may require strategic intervention and more frequent progress monitoring. Students performing significantly below expected levels and students failing to respond to interventions will require more intensive intervention and weekly progress monitoring. If a majority of the students in a class or grade are falling below benchmark standards, the next step may be evaluating the core curriculum to see how well it aligns with the district or state math standards. Math coaches need to determine whether benchmark assessments are being used consistently and effectively by teachers to identify student needs.

***Progress Monitoring*.** If students have been identified as needing additional support (i.e., tier-2) based on benchmark testing, then more frequent progress monitoring is recommended. While benchmark measures compare an individual student's performance to the average performance of other students, progress monitoring allows for an analysis of an individual student's performance over time relative to an expected rate of progress. See the chapter by Shinn for more information on this topic as illustrated in reading. If scientifically based assessment tools are used, student production responses (i.e., written answers) can be analyzed such that an individual's strengths and weaknesses can be identified through error analysis.

Several progress monitoring systems are commercially available to help teachers and math coaches monitor student mathematics performance. One example of a commercial progress monitoring system for mathematics is AIMsweb (Pearson Education, Inc., 2008). This system includes math measures for both early math skills (e.g., Early Numeracy and Quantity Discrimination) and mixed skill computation probes. Other similar commercially developed

CBM systems include Monitoring Basic Skills Progress (MBSP) Concepts/Applications and Computation measures (Fuchs, Hamlett, & Fuchs, 1999) and Yearly Progress Pro (CTB/McGraw-Hill, 2008).

These systems are typically linked to a data management system that is designed for ease of use. Most of these systems provide comprehensive data on student performance including whether students are mastering the material and which skills need additional review. The systems save teachers considerable time on summarizing student data and constructing student and class reports. The reports help teachers in communicating student performance levels with parents and guardians. Notably, many of these commercial programs can be used for both reading and mathematics.

***Program-specific Assessment.*** *Program*-specific assessments are those tests that accompany a published math curriculum. The tests fall into two categories: (a) placement testing and (b) mastery monitoring or criterion-referenced assessment. How well these assessments are designed will be addressed in a later section on curriculum evaluation. The questions about program-specific assessment included on the MPS Inventory are designed to provide information regarding how frequently and how effectively teachers are using the assessments to guide their instruction. Information about program-specific assessment recorded on the MPS Inventory may reveal a need for professional development in interpreting assessment results or in conducting error analyses.

***Assessment of Content Coverage.*** To ensure that struggling students make sufficient progress toward mathematics proficiency, teachers must be able to balance *content mastery* with *content coverage*. That is, teachers need to be able to predict whether their students will have covered the essential content during the time allocated. Content mastery at the expense of content coverage will preclude many students from acquiring those skills necessary for advanced math topics. Likewise, covering content without requiring students to perform adequately does little to assist students in meeting their academic goals. For example, introducing decimals skills to students who have not mastered basic fraction concepts will confuse some students and delay mastery of the newly introduced material. Teachers often feel pressure from their schools or districts to introduce topics at a rate far too fast for student mastery of even the most basic concepts. Although we understand these pressures, improving mathematics performance requires attention to *both* content coverage and content mastery. Information about content coverage will assist teachers in identifying those students who require additional instruction in order to make adequate progress.

### ***Curriculum and Instruction***

On the MPS Inventory in the area of Curriculum and Instruction we have included questions that address both *curriculum materials* and the *organizational variables of time allocation and instructional grouping*. In a 3-tier model, students may require different or additional curriculum materials, depending on their performance level. Core curriculum materials that are used primarily in general education classrooms may require modifying or supplementing for students in tier-2 and tier-3. Often, the core curriculum is not appropriate for use with tier-3 students and a replacement core program must be adopted. Because of the tension between mastery and coverage. With too many disconnected concepts not taught to mastery in many core mathematics programs, students with severe math deficiencies never “get good at anything” including critical perquisites for later mathematics success. Not unexpectedly, students learn to hate and/or avoid math.

Similarly, organizational variables may need to be altered for students not performing at grade level. Information regarding how time is allocated, how that time is spent, and whether and how students are appropriately grouped for instruction is included in this area.

### ***Professional Development***

The final area on the MPS Inventory addresses professional development needs. The questions in this area focus on two topics: Inservice Training Needs and In-class Coaching Needs. Information regarding how much and what type of inservice training teachers have received related to the topics of assessment, curriculum and instruction, and data utilization is recorded here. These questions are designed to highlight areas for which teachers may need additional support and/or training. Other questions pertain to whether procedures for conducting grade level team meetings are in place, and whether procedures for designing action plans have been developed.

The Professional Development area also includes questions on whether teachers are receiving in-class coaching as they deliver math instruction. Math coaches need information that will help them differentially allocate time spend with teachers in their respective classrooms. For example, some teachers may need more demonstration teaching than others to effectively implement a newly adopted instructional program.

## Math Action Planning

Action planning refers to designing instructional changes for *all* students. We have intentionally referred to action planning rather than intervention planning to encourage both general and special educators to work collaboratively to prevent math failure of students in tier-1 and tier-2 and to accelerate the math performance of students in tier-3. This kind of planning can occur at various times and involve various participants; however, action planning among grade-level teams has become more common (Johnston, Knight, & Miller, 2007). The team meeting provides a structured opportunity for teachers to learn about research-based instructional practices and obtain support for the implementation of these practices in their classrooms (Gersten & Dimino, 2001). Math coaches are typically responsible for scheduling grade-level team meetings, generating the meeting agendas, and facilitating the action planning discussion.

## *Curriculum and Instruction*

The next part of this chapter is organized around one of the two areas that focus directly on math action planning: Curriculum and Instruction. (The second area, Professional Development, is discussed later.) In this area we integrate available research with specific recommendations to help math coaches implement research-based instructional actions related both to evaluating, selecting, and modifying math curriculum materials and to selecting and implementing interventions that focus on classroom organization such as increasing instructional time and using appropriate instructional grouping.

### *Curriculum Materials*

Mathematics curriculum materials need to reflect a high degree of instructional *integrity*. That is, the materials should offer well-designed content, develop ideas in depth, and clarify the relations among topics. Commenting on the role that curriculum likely played in the results from the 2002 TIMMS research, Schmidt and colleagues (Schmidt, Houang, & Cogan, 2002) stated, "*The curriculum itself –what is taught- makes a huge difference.*" (p.12) and observed that the U.S. and Australia were the only TIMMS countries that lacked a national mathematics curriculum.

In the U.S., many consider the widely used commercial mathematics programs approved by state and district adoption committees as the *de facto* national curriculum (Cai, Watanabe, & Lo, 2002). Although the term "curriculum" is not technically synonymous with program, in this chapter, we use the terms curriculum materials and instructional programs interchangeably to refer to those commercially developed mathematics programs used by both general education and special education teachers.

Many educators are surprised to learn that most publishers do not routinely evaluate the effectiveness of their programs, either during development or once they are in classrooms (Reys, Reys, & Chavez, 2004). Because research is costly, publishers tend not to engage in extensive research on their programs. With limited scientific evidence on the effectiveness of math instructional programs, educators need to examine the programs carefully *prior* to purchasing and implementing them in their classrooms.

The following sections contain recommendations for selecting, evaluating, and modifying math instructional programs that will help educators make informed decisions about these materials. We also include recommendations for time and grouping, two classroom organizational variables that have been shown to have a significant impact on student performance.

***Curriculum Adoption***. Because curriculum materials are integral to the overall implementation of effective mathematics instruction, we recommend that educators use a carefully designed selection process when acquiring those materials. Stein, Stuen, Carnine, and Long (2001) described a systematic adoption process for the selection of reading programs that can easily be applied to math programs. In the limited space available, we discuss two critical features of the process below: time allocation and committee responsibilities.

The curriculum adoption committee often includes the math coach, general and special education teachers, and administrators. Because a thorough examination of math instructional programs requires a significant amount of time and effort, adequate release time needs to be allocated for committee members. This time is critical for activities including the review of relevant research in math, the design of screening and evaluation criteria based on that research, the initial screening of submitted programs, and then the thorough evaluation of those programs that pass the screening. If the committee members have, as we recommended, spent considerable time examining the programs, they are undoubtedly in the best position to make an informed decision. Having a committee select the programs to adopt for an entire school or district rather than having all teachers vote on the program options is *not* characteristic of many curriculum adoptions. For teachers in a school or district to feel comfortable with a committee decision, we recommend that the math coach assist individual committee members in communicating regularly and effectively with the groups they represent as they participate in the adoption process. (See Stein et al., 2001 for more details.)

***Curriculum Evaluation***. Objectively evaluating curriculum materials is complex and usually requires extensive training. The following recommendations serve only as an introduction to the curriculum evaluation process. Figure 3 contains a set of questions derived from both instructional research in math and instructional design that are useful in evaluating curriculum materials (Engelmann & Carnine, 1991; Przychodzian, Marchand-Martella, Martella, & Azim 2004; Snider & Crawford 2004). We have organized these questions into three categories: General Program Design, Instructional Strategies, and Assessment. (For more detailed information, see Kinder & Stein, 2006.)

*General Program Design.* This category includes questions related to instructional objectives and program coherence. In order to get a better sense of general program design, evaluators must examine both the scope and sequence and a series of sample lessons from selected levels.

Examining program objectives may provide the first indication of how systematically a program is designed. Ideally, the objectives should contain a statement of a measurable behavior. However, evaluators may find that many recently published programs contain objectives that describe *teacher behavior* rather than student behavior. For example, in our curriculum evaluation work, we found objectives similar to this one, "Introduce subtraction with regrouping." That objective identifies *what the teacher* is to do but not what the students are expected to learn. In contrast, an example of a well-designed student objective specifies exactly what the student will be able to do as a result of instruction (e.g., *Students will accurately regroup from the tens column to the ones column when given a set of mixed problems*.)

To develop competence in mathematics, students must understand the relationships inherent in the critical math content taught in their instructional programs. Therefore, another question under General Program Design addresses *program coherence* and focuses on the organization and integration of the content within the curriculum materials. One way to determine the extent of program coherence is to look for evidence that a newly taught strategy has been *integrated* with previously taught content. Another way of determining program coherence is by examining how well the program integrates instruction in computation with instruction in problem solving.

A more comprehensive way of establishing the degree of program coherence is by identifying whether the program is organized using a *spiral* or *strand* design. In programs using a spiral design, many topics are introduced at each level and repeated across many levels within and across grades. For example….Spiral mathematics programs are the most common in the United State. Typically, programs using a spiral design lack adequate initial instruction and review to promote student mastery. Lessons in these programs typically cover a different topic each day. Schmidt et al. (2002) referred to programs organized using a spiral design as “a mile wide and inch deep” (p.12).

Recently, more instructional programs are being organized using a strand design (Snider, 2004). These programs present fewer topics over a longer period of time and have a definite focus on student mastery. For example, (use the same content as for spiral) A unique feature of strand design is that lessons are organized around multiple topics. For example, a single lesson at the fourth-grade level might include some work on multiplication facts, some work on subtraction with regrouping, some work on fraction analysis, and some work on measurement.

Program coherence has been identified as a common characteristic of the curricula used in the top performing countries participating in international assessments such as the TIMMS. As a result, one of the recommendations of the National Mathematics Advisory Panel directly addresses program coherence:

> *Recommendation.* A focused, coherent progression of mathematics learning, with an emphasis on proficiency with key topics, should become the norm in elementary and middle school mathematics curricula. Any approach that continually revisits topics year after year without closure is to be avoided. (National Mathematics Advisory Panel, 2008, p. 22)

*Instructional Strategies.* In Figure 3, we present questions for examining how well the instructional strategies within a program are designed. Research reviewed by the Instructional

Practices Group of the NMP supports the use of *explicit strategy instruction* for low-achieving students and for those with MLD (Baker, Gersten, & Lee, 2002; Gersten, Chard, Jayanthi, Baker, & Lee, 2006; Ketterlin-Geller, Chard, & Fien, 2008; Kroesbergen & Van Luitt, 2003; National Mathematics Advisory Panel, 2008). For example, rather than relying on students to generate their own problem solving strategies to solve word problems by introducing them to a variety of options (e.g., drawing pictures or using manipulatives), according to the research literature, students are more likely to be successful if their teachers teach how and when to apply specific algorithms to the word problems. Therefore, the first question in this category directs evaluators to determine the degree to which the strategies in the instructional programs being examined are explicit. We recommend that evaluators locate where a strategy is first introduced and examine whether the steps in that strategy are clearly outlined at that point. Usually, the strongest instructional support for students is provided when a new strategy is first introduced.

The second question under this category addresses how *generalizable* the strategy is. Prawat (1989) suggests that efficient strategies be of intermediate generality. Strategies that are too narrow or of limited generality only apply to a small number of examples yet often require a great amount of instructional time. Strategies that are too broad are usually less explicit. For example, the common problem solving strategy "guess and check" is far too broad to be of use to young students who are struggling to solve complex word problems involving comparisons (e.g., Jane is 5 ft. 6 in. tall. If Mary is 6 inches taller than Jane, how tall is Mary?). Determining the level of generality is often quite difficult. Evaluators need to inspect the examples that accompany the strategies to determine if the strategy can easily be applied to a sufficient number of different examples.

Efficient strategy instruction requires that background knowledge and requisite component skills be identified and taught before the introduction of the strategy. Many programs either fail to identify critical component skills or they introduce the component skills simultaneously with the strategy. Having to master both a new component skill *and* the new strategy increases the instructional demands placed on students. For example, students may be introduced to the concept of "least common multiple" at the same time they are taught the strategy for "adding fractions with unlike denominators." Requiring that students learn both skills during the same lessons will likely cause confusion for some students. When examining instructional strategies, evaluators need to determine the critical component skills for each strategy and determine where and when those component skills are taught.

Once evaluators have examined carefully the quality of the instructional strategies, we recommend that they compare programs with respect to the *number of examples* provided for the strategies being taught. When selecting programs for students in tier-2 and tier-3, evaluators may want to err in selecting programs with *more* rather than fewer examples. For many teachers, eliminating some of the examples used during instruction is far easier than generating more examples.

In addition to the number of practice examples, evaluators need to examine the *type* of practice provided. *Discrimination practice* refers to a presenting set of examples that requires students to determine not only how but also when to apply a strategy. For example, after the introduction of addition of fractions with unlike denominators, the program should provide practice on a mixed set of problems in which some fractions have like denominators and others have unlike denominators. Discrimination practice increases the likelihood that students will consistently be successful when independently applying strategies to similar problems.

Research strongly supports certain types of review (Dempster, 1988). Well-designed programs include review that is *sufficient* (i.e., adequate for students to initially learn the content), *distributed* (i.e., practiced over time so that students do not forget what they have learned) and *cumulative* (i.e., integrated with previously related content). By examining the practice examples available for several newly introduced strategies, evaluators can determine the extent to which a program provides appropriate types of review.

***Assessment.*** The questions about in-program assessment in this section address the placement and assessment options that accompany commercial math programs. Evaluators need to examine the teacher manuals as well as any supplementary assessment materials to answer the questions on this topic. While the program-specific questions on the MPS Inventory focus on whether and how teachers use program-specific assessments, the questions from the Curriculum Evaluation Guidelines concern the quality and usefulness of those assessments.

First, evaluators need to determine whether programs contain a placement test with alternative placement options allowing students to be placed at different levels of the program aligned with their current mathematical skill levels. Options for lower level placement are particularly important for students who lack critical skills and have limited time to acquire them; these students and their teachers do not have the luxury of spending a great deal of time reviewing those skills they have already demonstrated mastery. That type of review should occur during independent work.

Next, evaluators should determine if recommendations for acceleration (i.e., "skip lessons 14-16 if not needed) and remediation (i.e., "reteach lessons 14-16) are based on the program assessment results. Again, these recommendations should help ensure that the math instruction is efficient and effective. Finally, evaluators need to establish the extent to which program assessments are aligned with instruction. This alignment is necessary for teachers to use the program assessments to make informed instructional decisions regarding student progress and mastery of the content.

*Curriculum Modification.* Based on our experience, the design of the instructional strategies in a math curriculum should be given greater consideration than the other components when evaluating instructional programs. (See Mathematics Curriculum Evaluation in Figure 3.) First, instructional strategies are the most difficult for teachers to modify because teachers would need a more sophisticated knowledge of math content than the literature suggests they have (Hill, Rowan, & Ball, 2005; Ma, 1999; Schmidt et al., 2002). Secondly, even if teachers have extensive mathematics backgrounds, few teachers have had coursework in the area of instructional design. Finally, teachers who have both adequate mathematical knowledge *and* instructional design expertise rarely have time to design new instructional strategies or field test those strategies to determine if they are effective. Therefore, curriculum materials that contain well-designed instructional strategies should be given greater consideration in the selection process.

Modifying specific features of strategy instruction may be far less complicated for some teachers, however. In some instructional programs, the problem-solving strategies may be well designed but the programs may lack sufficient practice and review opportunities. Teachers can supplement these programs by first adding more practice examples during initial instruction, then building in more systematic review throughout. Although easier than designing strategies, adding practice and review can be extremely time-consuming, especially when attempting to carefully integrate new and previously introduced content. The difficulty inherent in curriculum modification underpins the necessity of engaging in a thorough, systematic review of instructional programs prior to selecting them for use. While no individual instructional program will meet the needs of all students, programs that require less modification are undoubtedly preferable. (For a resource for program modification, see Stein, Kinder, Silbert, & Carnine, 2006.)

***Organizational Variables***

*Time and Grouping.* In their review of the teacher effectiveness literature in the 1980's, Rosenshine and Stevens (1986) called attention to the importance of both allocating sufficient time for instruction and ensuring that students are engaged during that time. As a result of that early work, more recent research has focused on ways of increasing allocated and engaged time through structural changes within a classroom and/or school. In this section, we briefly outline several research-based practices that are designed to increase the amount of high quality instructional time students receive as examples of the kind of changes that can be made through action planning. These practices include: double dosing, the strategic use of work checks, peer tutoring, and instructional grouping.

Double dosing, an increasingly popular way to augment instructional time for math (Cavanagh, 2006; Wanzek & Vaughn, 2008), usually involves adding a second session of math instruction during the regular school day. The instruction in the second session may entail pre-teaching or re-teaching content from the adopted curriculum materials (Lalley & Miller, 2006) or supplementing those materials with additional content (Peele, 1998).

Adding a *work check* to the instructional schedule is, in some ways, similar to double dosing. A work check is a 15-20 minute teacher-directed activity, preferably scheduled in addition to the time typically allocated for math instruction. During a work check, the teacher provides specific feedback to students and helps them errors on their independent work (Stein, Kinder, Silbert & Carnine, 2006). The sooner student errors can be identified and remedied, the greater the probability of preventing serious deficiencies that would require more intensive intervention. Put another way, the longer a student practices completing a problem the wrong way, the more difficult that practice is to correct.

Cooperative learning and classwide peer tutoring (see Greenwood, this volume), both of which can occur within or outside of the school day, have consistently been shown to have positive effects on student performance in math perhaps because of the likelihood that students are more engaged during those activities (Baker, Gersten, & Lee 2002; National Mathematics Advisory Panel, 2008; Slavin & Karweit, 1985). In Classwide Peer Tutoring, for example, all students serve as both tutors and tutees inevitably resulting in increased time and attention to math activities (Fuchs, Fuchs, Yazdian, & Powell, 2002; Greenwood, 1991).

As with cooperative learning and peer tutoring, support for the use of flexible, homogeneous instructional (i.e., skill-level) grouping to address student needs more efficiently is longstanding (Lou et al., 1996; Slavin, 1987). Interestingly, instructional grouping issues are somewhat analogous to issues related to academic engagement time. What makes instructional grouping an effective strategy is less about *where* the students receive instruction (e.g., in a whole class, small group, resource room) and more about *how* and *what* they are taught. Similarly, academic engaged time is less about the minutes that are allocated for instruction and more about students being engaged during those minutes. Attempting to teach a small group of low-performing students using curriculum materials that are too difficult will not likely improve their math performance. Likewise, allocating a double dose of a poorly designed instructional program to struggling students is also not likely to yield positive results. While evidence suggests that it is a good practice to take time and grouping into account during action planning, educators need to always remember to integrate that information with information from other areas of the MPS Inventory.

### ***Professional Development***

A primary goal of professional development is to help teachers effectively implement research-based practices into their classroom routines. Professional development activities that have a clearly identified purpose, are concrete and practical, and are tied directly to a school's overall efforts toward improvement appear to be most likely to lead to lasting change (Gersten, Chard, & Baker, 2000; Gersten, Morvant, & Brengelman, 1995; Little & Houston, 2003). As noted previously, limited research on effective instruction is available in the area of mathematics. Even less research is available on how best to prepare teachers to deliver high quality math instruction (Ball, Lubienski, & Mewborn, 2001; Ma, 1999). However, the reviews of the existing math professional development literature have led us to conclude that effective professional development must also focus on relevant and research-based content and provide opportunities for teachers to engage in active learning (Cohen & Hill, 2000; Garet, Porter, Desimone, Binnan, & Yoon, 2001; National Mathematics Advisory Panel, 2008).

We have organized our discussion of professional development around two distinct but related types of activities, (a) inservice training, and (b) in-class coaching. We use the term inservice training to refer to any training that occurs outside of the classroom. Inservice training can range from a 2-hour meeting after school with an individual teacher to a 5-day workshop during summer break for an entire school faculty. In-class coaching, on the other hand, is more often highly individualized and, as the name indicates, occurs within a teacher's classroom. Ideally, the math coach designs professional development to promote a seamless integration between inservice training and in-class coaching. For example, once new instructional programs have been adopted, the math coach would schedule inservice training opportunities that target specific program features (e.g., error correction procedures) followed closely by in-class coaching on the implementation of those program features. The following sections on describe how a math coach might use the MPS Summary Form to guide professional development using both inservice training and in-class coaching.

### *Inservice Training Needs*

The Professional Development area of the MPS Inventory is designed to direct math coaches to those topics for which teachers demonstrate greatest need. As indicated on the MPS Summary Form (see Figure 2), the topics under Inservice Training are assessment, curriculum and instruction, and data utilization. Regardless of the topic, inservice training should be focused on specific research-based content with an emphasis on helping teachers understand how that content can be applied to their classrooms.

In a 3-tier model designed to promote positive math performance, inservice training related to various assessment types is critical. Teachers need to understand how to choose assessments that will best inform their instruction, and then how to accurately and reliably administer, score and interpret information from those assessments. For example, some teachers will need considerable practice before they are able to reliably score the math-CBM probes that involve counting correct digits per minute. Another important assessment topic that lends itself to inservice training is the correct use of program-specific assessment. Although information on these assessments is usually shared during initial inservice training on newly adopted programs, teachers may require more extensive and review opportunities to explore the usefulness of the assessments and how and when to use them.

The need for a coherent, focused curriculum (Schmidt, Houang, & Cogan, 2002) is, in part, related to research documenting that many U. S. teachers are simply unprepared to teach mathematics (Ball, Hill, & Bass, 2005; Ball, Lubienski, & Mewborn, 2001; Ma, 1999). As stated earlier, while no curriculum materials will meet the needs of every student, having access to well-designed instructional programs may play an important role in improving the math performance of our students (Schmidt et al., 2007). Given the importance of these instructional programs, teachers need extensive preparation and ongoing support in implementing them.

Before attributing a lack of student progress to the instructional program, the math coach along with grade-level teams should feel confident that the program is being implemented with fidelity, i.e., implemented in the way the program authors intended. Using both inservice training and in-class coaching to address issues of implementation is usually required. Action planning that addresses inservice training in the area of curriculum and instruction certainly encompasses more than program implementation. Additional topics for inservice training in this area include strategic program modification, and, as mentioned earlier, the modification of organization variables such as scheduling and grouping.

The final area designated under inservice training is data utilization. This area, is in many ways, the most complex. Teachers need to understand if and when their students have learned mathematical content. Many teachers are not explicitly taught in their teacher preparation programs how to use objective measures to evaluate student learning. Moreover, teachers are not often taught how to link assessment data to instructional decision making. Therefore, inservice training targeted at how to use data to make instructional decisions is essential (Baker, Gersten, Dimino, & Griffiths, 2004; Little and Houston, 2003).

We think that the grade-level team meeting may be the most appropriate and convenient means of reporting data and engaging in shared decision making. To that end, many teachers will need professional development on the procedures that make grade-level team meetings and action planning efficient and productive. Therefore, in the area of data utilization, we include both inservice activities related to the implementation of grade-level team meetings and inservice on how to use data within the team meeting to make instructional decisions and design action plans. In addition, we strongly recommend that those persons who are knowledgeable and who have experience using both formative assessment data and diagnostic information be included as members of the grade-level team (e.g., school psychologists).

***In- Class Coaching Needs***

From their work with peer coaching, Joyce and Showers (2002) estimated that 90% of teachers receiving in-class peer coaching were likely to implement newly learned teaching practices compared with only 60% of teachers receiving demonstrations and practice, and just 10% of teachers receiving demonstrations alone. While inservice training provides a context for understanding new instructional practices, in-class coaching provides direct support to teachers as they implement those new practices.

The purpose of in-class instructional coaching is to improve the teacher's delivery of mathematics instruction. Though inextricably related, we have divided in-class coaching into two broad areas: (a) instructional, and (b) behavioral. The in-class coaching needs of teachers will vary depending on both teacher skills and student needs. Teachers who teach many struggling students will undoubtedly need greater instructional support, whereas teachers who have weak classroom management skills may need in-class coaching on implementing positive behavior support.

In-class coaching sessions provide different levels of support ranging from less intrusive to more intrusive. An example of less intrusive in-class coaching involves the math coach observing the delivery of a math lesson. In contrast, during more intrusive in-class coaching sessions, math coaches model specific math lessons or demonstrate the use of a reward system that reinforces effort and attention. Because in-class coaching can be anxiety-producing for many teachers, we suggest that math coaches establish well-defined objectives and communication procedures to facilitate a productive collaboration.

Providing professional development that integrates data-based decision making and research-based instructional practice provides the basis for a problem solving model likely to promote positive math outcomes for all students. The more teachers can experience firsthand an association between problem solving and student progress, the more likely they will be to sustain their successful teaching practices over time (Gersten & Dimino, 2001; Moss, Jacob, Boulay, Horst & Poulos, 2006).

# CONCLUSIONS

The title of this chapter, Promoting Positive Math Outcomes, is intentionally general in nature and broad in scope. Our purpose was to introduce readers to a comprehensive problem solving approach to improving student performance in mathematics. In the chapter we have drawn from the literature in school psychology, general education, special education, and education policy. We have taken into account large scale reform initiatives such as Comprehensive School Reform (Borman et al., 2003); Reading First (Moss et al., 2006); Response to Intervention (Fuchs & Deschler, 2007). As mentioned earlier, these initiatives are essentially problem solving models in areas where student performance does not match expectations.

Throughout the chapter, the focal point for implementing the approach has been the math coach. We assigned the math coach the responsibilities of coordinating research-based assessment and action planning activities. Consequently, the math coach became the point person for coordinating the professional development necessary to implement all of the activities with fidelity.

We designated the math coach to be the central figure of the problem solving approach so that readers would be able to concentrate on the *what* rather than the *who* as they were introduced to various activities. Historically, classroom support in the form of consulting teachers (Gersten, Darch, Davis, & George, 1990), behavior specialists (Metzler, Biglan, Rusby, & Sprague, 2001) or instructional coaches (Moss et al., 2006) has been shown to increase the likelihood that teachers will acquire the skills necessary for successful implementation of the research-based activities. Having mastered the activities, the teachers then are more likely to sustain their use (Gersten, Chard, & Baker, 2000).

Can the problem solving approach we propose here for providing multi-tiered, early intervening services be implemented without a math coach? Of course, it can. While the math coach is clearly an appropriate designee for the role of coordinator, the responsibilities of the math coach most certainly can be distributed among those with suitable expertise. For example, given the training school psychologists receive in measurement and testing, they are often the best prepared to coordinate the assessment, data utilization and even some error analysis activities for a district, school or individual teacher. As a member of a grade level team and collaborator, school psychologists can contribute to action planning by introducing teams to research-based activities drawn from the school psychology literature.

The participation of school principals and other administrators also are integral to the successful implementation of a comprehensive problem solving approach (Lau et al., 2006). The responsibility for coordinating professional development activities frequently lies with the school principal, who has the most control over budget and scheduling. Moreover, principals are essential participants in critical placement decisions, especially when those decisions involve students with disabilities.

Just as a championship basketball team may be carried by a star player, so is it possible for schools and teachers to be carried by a star math coach. However, most championships are won through the contributions of all team members. So it is with the math improvement. All of the members of the team must be engaged in deliberate, focused decision making and a commitment to the implementation of research-based instructional practices in order to achieve the desired results.

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**Figure 1. Examples of Questions from the Mathematics Problem Solving (MPS) Inventory**

**I. Assessment**

**A. Student Performance Measures**

**A1. Benchmark Assessment:**
Are benchmark assessments being administered throughout grade levels consistently?

**A2. Progress Monitoring**
Are progress monitoring assessments administered during the school year and are these assessments administered frequently enough to discover when students are not making satisfactory progress?

**A3. Program-specific Assessment**
Are placement assessments administered at the beginning of the school year to determine starting points for students in Tiers 2 and 3 in all materials?

**A4. Assessment of content coverage:**
Have content coverage goals (pacing guides) been established for Tier 1 students in the core program?

**II. Curriculum and Instruction**

**B. Materials and Organization**

**B1. Curriculum Materials for Each Tier**
Are materials and instruction structured sufficiently to meet the needs of Tier 1 students?

**B2. Procedures for selecting, evaluating and modifying curriculum materials:**
Have core materials been modified to meet the needs of students in tier-2?

**B3. Organization Variables: Time & Grouping**
Is sufficient time for instruction in math allocated to Tier 3 students?

**III. Professional Development**

**C. Inservice Training Needs**

**C1. Assessment**
Are teachers receiving sufficient support to reliably administer and score progress monitoring assessments?

**C2. Curriculum & Instruction**

Have all teachers and assistants have received sufficient in-service training to prepare them to teach the supplementary and intervention programs?

### C3. Data Utilization

Do procedures exist for teams to design action plans to solve problems of inadequate student performance or progress?

## D. In-Class Coaching Needs

### D1. Instructional Coaching

Are all teachers and assistants receiving high-quality in-class instructional coaching on newly adopted curriculum materials?

### D2. Behavioral Coaching

Are all teachers and assistants receiving high-quality in-class coaching in implementing positive behavior supports.

**Figure 2**

**Math Problem Solving (MPS) Inventory**
**Summary Form**

| | | |
|---|---|---|
| Name and Title: | School/Grade Level: | Date Created: |

**Based on data from the MPS Inventory, check all topics in each area where an action may be needed.**

| **I. Assessment** | **II. Curriculum & Instruction** | **III. Professional Development** |
|---|---|---|
| **A. Student Performance Measures**<br>☐A1. Benchmark assessment<br>☐A2. Progress monitoring<br>☐A3. Program-specific assessment<br>☐A4. Assessment of content coverage | **B. Materials & Organization**<br>☐B1. Curriculum materials for each tier<br>☐B2 Procedures for selecting, evaluating and modifying curriculum materials<br>☐B3. Organizational variables: time & grouping | **C. Inservice Training Needs**<br>☐C1. Inservice – Assessment<br>☐C2. Inservice – Curriculum & instruction<br>☐C3. Inservice – Data Utilization<br><br>**D. In-Class Coaching Needs**<br>☐D1. In-class instructional coaching<br>☐D2. In-class behavioral coaching |

**Figure 3. Mathematics Curriculum Evaluation**

**I. General Program Design**

A. Do the lessons include objectives with measureable student behaviors?
B. Are newly taught strategies integrated with those previously taught?
C. Is there a balance between computation instruction and problem-solving instruction?
D. Is the program organized using a spiral or strand design?

**II. Instructional Strategies**

A. Are strategies explicitly taught in the program?
B. Are the strategies appropriately generalizable—neither too narrow nor too broad?
C. Are critical component skills taught prior to the strategy?
D. Are there adequate examples provided for instruction?
E. Are discrimination examples included?
F. Are examples included for cumulative review?

**III. Assessment**

A. Does the program include a placement test with options for various starting points?
B. Do in-program assessments include recommendations for acceleration or remediation?
C. Are the in-program assessments carefully aligned with instruction?