

A Model of MTSS: Integrating Precision Teaching of Mathematics and a Multi-Level Assessment System in a Generative Classroom

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In the generative classroom, teachers provide well-designed learning environments that result in the combination, recombination, and reorganization of repertoires such that new untaught repertoires are likely to occur. One component that can contribute to such generativity is Precision Teaching (PT), a frequency building instructional intervention. A multi-level assessment system, combined with evidence-based practices of teaching and learning can result in systematically accelerated student progress in mathematics thus enhancing RtI frameworks. Additionally, PT contributes to nourishing a Multi-tiered System of Support (MTSS) implementation by creating a common language between and amongst students, teachers, families, and administrators. In this unique blended system, the data collected by administrators, teachers, and students are continuously assessed and used to inform instruction and teacher training needs. A graphic presentation of these data on the Standard Celeration Chart (SCC) guides goal setting and interventions. This paper presents a case study detailing the rapid progress of a class of students during one academic school year using PT.

Keywords: Response to Intervention, Multi-Tier System of Support, Precision Teaching, Multi-Level Assessment System, Progress Monitoring, Curriculum-Based Measurement, Frequency-Based Instruction, Education Reform, Responsiveness to Intervention, Response to Intervention, Mathematics, Assessment, Intervention, Inclusion, Generative Instruction, TAPS, Talk Aloud Problem Solving

INTRODUCTION

Response to Intervention (RtI) was developed on a foundation of research that helped to identify the need for multiple tiers of service delivery in education to meet the learning needs of all students. These tiers, or levels, vary in terms of the intensity of intervention needed, as well as in the manner in which data inform each tier of service delivery (Vaughn & Linan-Thompson, 2003). Batsche (2014) identified

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one key difference that defines the multi-tiered method of service when IDEA was reauthorized in 2004. "The tiers were now defined in terms of *intensity* (time and focus) of instruction rather than as a place, provider, or instructional strategy. In this new context, theoretically any tier of instruction could occur in any place" (p.183). The term Multi-Tier System of Supports (MTSS) is used to describe the larger framework that encompasses an RtI model. Specifically, MTSS refers to a research based framework driven to create successful and sustainable system change and provide the most effective instruction possible to every student, which includes those with learning deficits and those with advanced learning needs (Riccomini & Wetzels, 2009).

Employing MTSS places the RtI model in the center of the educational organization. As our needs, discoveries, and trends in education evolve, the movement to implement evidence-based practices requires us to use instructional interventions that blend the learning sciences with our knowledge of healthy social environments. Any school system, whether it be an independent, charter, or contract school or part of a public school district, can take advantage of the methodologies arising from MTSS. However, there are several variables that significantly impact the effectiveness of MTSS systems, such as the: a) extent to which sensitive instructional placement procedures are employed, b) degree to which high quality teaching methodologies are used, c) depth and breadth of teacher training and support initiatives, and d) adequacy of student assessment systems and procedures in producing improved outcomes.

Certainly, one variable that greatly impacts RtI for vulnerable and at-risk learners is the degree to which the initial assessment procedures help to inform precise instructional placement. The use of homogeneous skill groupings is predicated on the assumption that children with marked skill deficits will learn better and make more progress when their teacher is best equipped to meet the specific challenge. When the primary goal of academic instruction is to close an academic gap, then relatively homogeneous skill groupings are highly preferable to very divergent, heterogeneous skill groupings because of the specific and intensive instruction that is needed to address skill deficits. When schools and teachers select reputable curricula that align with large-scale policies in education such as the Common Core State Standards, many students are likely to benefit. However, accelerated academic skill growth, which goes beyond what typically occurs for students with learning challenges, requires a much greater emphasis on diagnostic and prescriptive solutions that enhance a lesson-by-lesson approach to instructional planning.

Such diagnostic and prescriptive assessments often result in identifying component skills that make up the composite performances that occasioned the assessment in the first place. Learners who have problems mastering the same composite skill may experience this as a result of missing different components. In the generative classroom as described here, carefully identifying, establishing, and practicing these components may result in success with the composite performance with little or no direct teaching of the composite, hence the term *generative instruction*. Generative instruction, defined by Johnson and Layng (1992, 1994), is rooted in important discoveries from basic behavior analytic laboratory research (Andronis, 1983; Andronis, Goldiamond, & Layng, 1983; Epstein, 1981, 1985, 1991) and applied behavioral research (Alessi, 1987). What results from this generative approach is the rapid acquisition of critical component skills that facilitate the combination, recombination, and

reorganization of repertoires such that new, untaught repertoires are likely to occur. In this sense, not only would advanced algebraic skills be more likely to emerge without explicit instruction using a generative approach to learning, so would bursts of creativity and scientific discovery (Epstein, 1991; Goldiamond & Layng, 1983; Pryor, Haag & O'Reilly, 1969; Sidman, 1994).

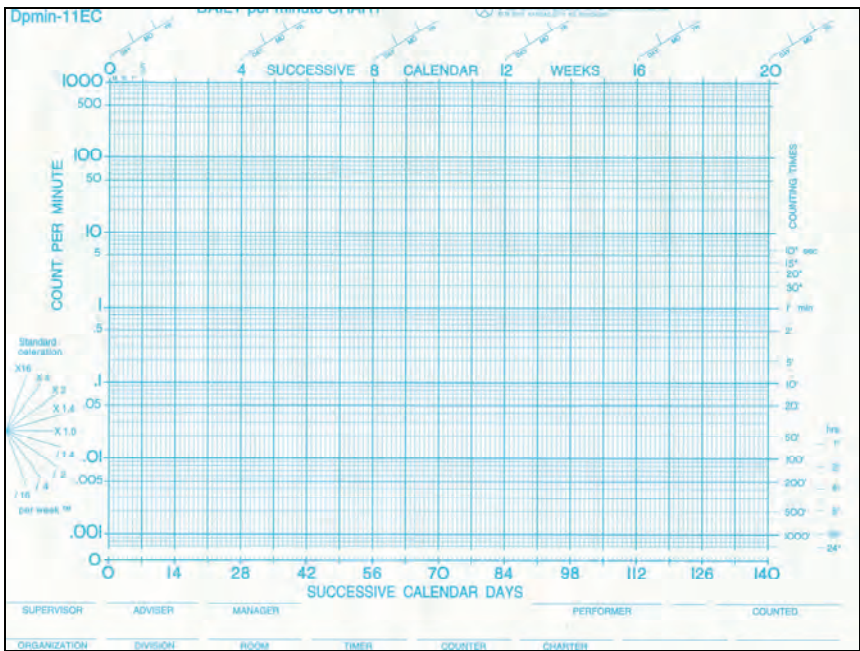
Many evidence-based practices can be employed in the context of an MTSS system to achieve generative outcomes. These include: a) the content analysis and sequencing of Direct Instruction (Archer & Hughes, 2011; Engelmann & Carnine, 1982) b) explicit instruction (Hunter, 1994; Markle, 1990; Tiemann & Markle, 1991); c) Precision Teaching (Lindsley, 1990); d) dynamic assessment systems (Malmquist, 2004); e) student-driven motivation systems with social and emotional learning, using a constructional approach (Colvin, 2004; Goldiamond, 1974; Latham, 1998); f) strategy teaching, such as Talk Aloud Problem Solving (Robbins, 1996, 2011, 2014) and questioning strategies (Robbins, Layng, & Jackson, 1995); as well as g) comprehensive professional development opportunities (Johnson & Street, 2004).

A critical and unique instructional feature incorporated in the generative classroom described in this paper is the application of Precision Teaching (Johnson & Street, 2013; Lindsley, 1990, 1991), which can be used to accelerate learning outcomes while informing the instructional process. This highly effective teaching framework relies on frequency-based practice as well as the notion of component/composite analysis (Johnson & Layng, 1992). Component/composite analysis involves breaking larger, more complex skills down into their distinct component parts which are then targeted for frequency-based practice. The frequency-based practice yields daily data points charted on a Standard Celeration Chart (Calkin, 2005; Kubina & Yurich, 2012; Pennypacker, Koenig, & Lindsley, 1972) that reveal small, yet crucial increments of growth on the component skills that form the larger composite skills (White & Haring, 1980). The data on a Standard Celeration Chart are indicated as the number of correct and incorrect movements, or units, achieved by the student during that timing interval. Students typically complete several one minute timings on a specific component skill and then graph the "best" performance of the day on the "Daily per Minute" Celeration Chart. The teacher analyzes the graphed data across practice sessions and determines if the rate of learning, or celeration, is adequate enough for the student to achieve fluency in an efficient manner. If the student does not seem to be making sufficient progress, additional instruction or frequency-based component skill practice is prescribed. The goal of Precision Teaching is fluency, which Johnson & Layng (1996) defined as "...flowing, effortless, well-practiced, and accurate performance" (p. 281).

Ultimately, Precision Teachers are primarily interested in helping students build fluency on individual component skills so the skills become automatic and readily accessible by the student when working on composite skills and their combination. Precision Teaching further provides a means of formative evaluation, which results from monitoring performance of the composite skills while the component skills are still being developed. For instance, a teacher may determine that a student incorrectly answering complex multiplication problems has deficient component skills, including quickly solving basic math facts and adding columns of numbers from right to left. The teacher would then incorporate isolated frequency-based prac-

tice in these two component skills until the student reaches rate-based mastery criteria, which is often defined as 60 correct digits written in one minute on most math computation skills. At the same time, the teacher may continue to monitor performance on answering complex multiplication problems with the assumption that as component skill fluency increases, composite skill fluency will also steadily improve. If composite skill fluency is not steadily improving, it is assumed that other deficient component skills need to be identified and practiced under timed conditions at least 3-5 times per week until the rate-based mastery criterion is achieved. The instruction preceding frequency-based practice on a particular skill can occur in any instructional arrangement, methodology, or design (Lindsley, 1991). This is especially relevant in RTI classrooms as students moving through instructional tiers most likely require a variety of instructional approaches depending on their individual needs. As long as the teacher is collecting data while charting and analyzing it using the Standard Celeration Chart, all the tools needed to know if the student is learning efficiently are available to the teacher.

Figure 1. The Standard Celeration Chart Used to Track Frequency-Based Performance



a successful MTSS system in which Precision Teaching (Lindsley, 1990) and a Multi-Level Assessment System (Malmquist, 2004; Moors, Weisenburgh-Snyder, & Robbins, 2010) were integrated into a generative classroom. The accelerated academic gains in math achieved by the participants are described below.

A CASE STUDY

Setting

This case study was conducted at a private school in Seattle. The student population of approximately 70 students had not experienced academic or social success in traditional public or private schools. Most students were identified with various mild to moderate disabilities. All students demonstrated some degree of academic deficit, typically ranging between six months to three years behind same age peers at the elementary school level.

Assessment Sequence & Measures

A Multi-Level Assessment System (Malmquist, 2004) was used in this case study to evaluate student learning outcomes. The specific system elements selected were driven by the important evaluation questions we sought to answer for each student following the principles of Deno's (1985) Problem-Solving Model. This evaluation system included Macro, Meta, and Micro Levels of analysis (Malmquist, 2004; Moors, Weisenburgh-Snyder, & Robbins, 2010).

Macro Level Assessment. The first step in the assessment sequence involved Macro Level assessment to examine the entering math skills of all students. Macro Level Assessment included norm-referenced achievement tests that were administered: (1) at the beginning of the school year to inform the instructional placement process and (2) at the end of the year to determine the general effectiveness of instructional programming while informing future teacher training needs. From the list of measures that were determined to have adequate technical adequacy, specific norm-referenced achievement tests were selected for the Macro Level Assessment using the following criteria:

- 1) Is there a close match between what is assessed and what is likely to be taught (i.e., testing/teaching overlap)?
- 2) Is the assessment instrument widely used both regionally and nationally, such that major stakeholders are more likely to share a common framework for interpretation of results?
- 3) Does the assessment instrument allow for meaningful pre- and post-testing measurement to help determine instructional impact within the same academic school year (i.e., September-June)?

In the current case study, two norm-referenced achievement tests were used to determine general guidelines for placement of students into homogeneous instructional groups. First, math subtest scores from the *Woodcock-Johnson Tests of Achievement® III, Basic Battery* (Woodcock, McGrew, & Mather, 2001) were analyzed to determine relative skill proficiency and specific instructional needs. Because this assessment instrument includes production-type responses from students rather

than a multiple-choice format, more detailed item analysis was possible and assisted in instructional placement decisions.

The *Iowa Test of Basic Skills* (ITBS) (Hoover, Dunbar, & Frisbie, 2001) was administered the following day. The ITBS math related subtests that were administered included: (1) Concepts and Estimation, (2) Problem Solving, and (3) Math Computation, yielding scores for each individual subtest as well as a Math Total Score. In the present example, the students' chronological grade levels were used to select the appropriate testing level of the ITBS. If a student's entry-level basic skills were known to be greatly below typical peers, out-of-level testing was considered as an alternative to grade-level measurement to allow for more sensitive measurement. However, this was not an issue with students included in the current case study.

Meta Level Assessment. The next step in the assessment sequence was to use Meta Level data to provide more precise measures of academic skill performance. Meta Level Assessment is characterized by an increased frequency of administration and a higher level of sensitivity to small, incremental skill growth that is unlikely to be detected at the Macro Level. As Waldron, Parker, and McLeskey summarized (2014), "Research has revealed that the most critical factor related to the effectiveness of using CBM for progress monitoring concerns how teachers use these data to make instructional decisions" (p. 163). In this example, Curriculum-Based Measurement (CBM) tools that were closely aligned to the curricular content were administered on a weekly basis. The measurement materials selected included: 1) *Monitoring Basic Skills Progress (MBSP)*, *Math Computation* (Fuchs, Hamlett, & Fuchs, 1990) and 2) *Monitoring Basic Skills Progress (MBSP)*, *Math Applications and Problem Solving* (Fuchs, Hamlett, & Fuchs, 1994).

In the beginning of the school year, probes from three different grade levels were administered, scored, and interpreted to facilitate appropriate instructional placement and to determine a progress monitoring level that would be sensitive to growth over time. In addition to helping form cohesive instructional groupings, the baseline CBM scores also provided the basis for annual, measurable goals that were set and depicted using a time series graphic display of data (Deno, Fuchs, Marston, & Shinn, 2001). Each CBM graph included: (1) baseline data at a measurement level that was either at the student's chronological grade level, or at the highest grade level possible using out-of-level-testing procedures if necessary to achieve appropriate sensitivity to growth over time; and (2) an annual goal depicted on the graph, with an aimline (a projection of growth) drawn from baseline data. The graphed CBM performance data enabled an analysis of trend in performance to be determined in comparison to the aimline using the well-established practices of formative evaluation (Deno, 1985; Fuchs & Fuchs, 2008; Jenkins & Fuchs, 2012; Shinn, 1989; White & Haring, 1980).

Micro Level Assessment. The final step in the assessment sequence was to collect Micro Level data to further inform instructional decision-making. Micro Level Assessment requires daily data collection using measures that are highly sensitive to growth over time (Johnson & Layng, 1992; Lindsley, 1990). In the MTSS model discussed in this paper, the Micro Level Assessment was informed by Precision Teaching data. These data included measuring progress on component skills such as answering

basic math facts and composite skills such as the completion of complex arithmetic problems. Both level changes as well as slope, or celeration, depicting growth over time were analyzed to determine if a student was making adequate progress (Kubina & Yurich, 2012; Johnson & Street, 2004; White & Haring, 1980).

Placement Procedures

After analyzing these three layers of data, students were placed into homogeneous instructional groups. In this case, the math subtest results from the ITBS and WJ-III were analyzed first to determine which students were functioning at their chronological grade level and those who were not using norm-referenced comparisons. Given the number of enrolled students and number of teachers that were expected to run math groups during the school year, a sketch was created of preliminary instructional groups based on the results obtained from the initial assessment. Next, data from the Meta and Micro Levels were carefully considered to solidify instructional groupings. The core administrative staff of the school, including the Executive Director, the Principal, and the Director of Student Assessment, worked with the faculty to finalize the groupings.

For each instructional group, a blend of curriculum materials and instructional approaches were identified. Because an important feature of this instructional approach was that student data drove each decision made, the initial curriculum and instruction chosen were considered to be “hypotheses” and amenable to change as needed. For instance, it was determined that the instructional needs of the students in the present case study closely paralleled the scope and sequence of the *Saxon Math 54* and *Saxon Math 65* curricula (Hake & Saxon, 1994, 1995).

It is important to note that after initial placement decisions were made, teachers and administrators continued to use each layer of the Multi-Level Assessment System to inform the next. Daily decision-making was possible using Precision Teaching performance outcomes (Micro Level Assessment). Trends in performance from the weekly CBM probes (Meta Level Assessment) were used to validate the efficacy of the math curriculum and Precision Teaching instructional programming. The Meta Level data further enabled accurate predictions to be made regarding larger skill gains that were expected by the end of the school year using more widely accepted, but less sensitive, measures of skill improvement and achievement, such as the *ITBS* and *WJ III* (Macro Level Assessment). A flowchart illustrating this data based decision-making model and the relationship between assessment and intervention is depicted in Figure 2.

Participants

There were ten students included in the math class examined in this case study. All students were male. Ethnic breakdown included five students (50%) who were Caucasian, one (10%) was mixed race African American / Indian, and four (40%) were of Asian descent. Using their chronological grade placements, four of the students (40%) were considered to be in 4th grade, five students (50%) were considered to be in 5th grade, and one student (10%) was considered to be in 6th grade. However, on average, the students were performing between the end of third-grade and beginning of fourth-grade level based on their initial *ITBS* scores. Special edu-

cation eligibility categories included Learning Disability, Attention Deficit Disorder, Behavior Disorder, and Gifted. A description of the participants is presented in Table 1. Materials included *Saxon Math* books (Levels 54 and 65), frequency-based math practice materials, pencils, paper, Standard Celeration Charts, and one timer for each student. There were three Precision Teaching wall charts posted in the classroom as well to track student mastery of targeted math skills including basic addition/subtraction facts, multiplication/division facts, and more complex math computation skills.

Figure 2. Flowchart of Data-Based Instructional Decision Making

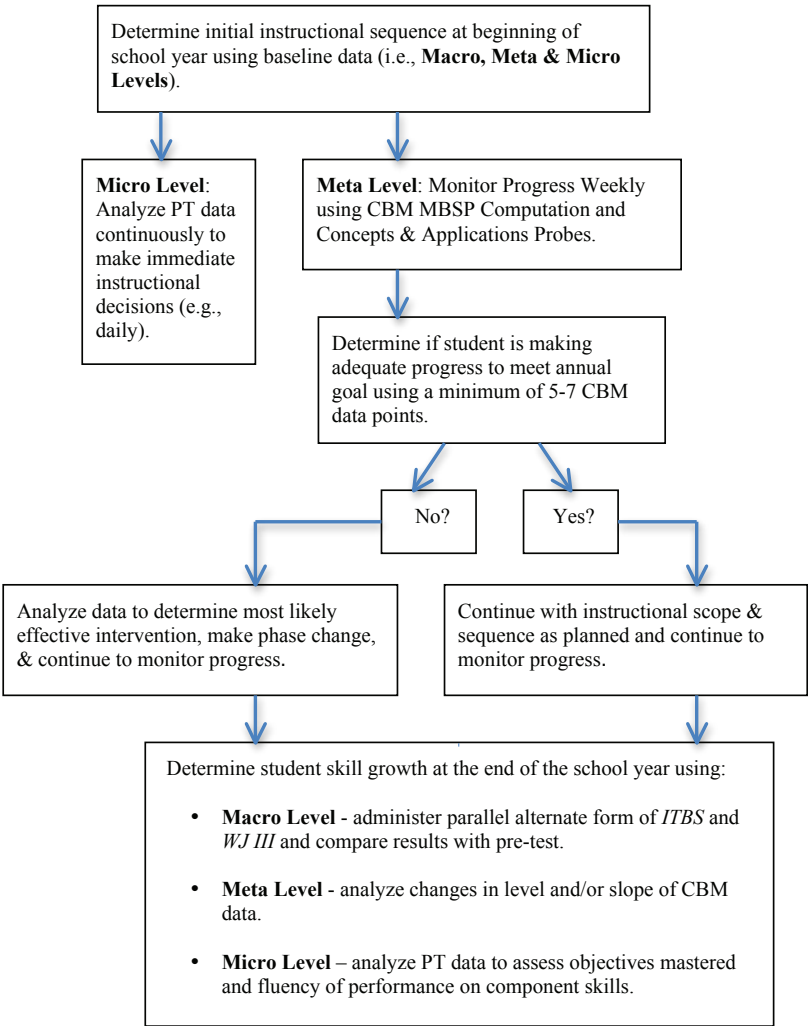


Table 1. Description of Study Participants

ID	Grade	Race	SPED
S1	4	A	none
S2	4	A	LD/ADD
S3	4	C	none
S4	4	C	ADD
S5	5	AA	none
S6	5	A	BD
S7	5	A	LD
S8	5	C	LD
S9	5	C	LD/Gifted
S10	6	C	none

Note. ID = student identification number; A = Asian; C = Caucasian; AA = African American; SPED = Special Education Eligibility Criteria; LD = Learning Disability; BD = Behavior Disorder; G = Gifted.

Classroom Implementation

One teacher provided the intervention to the group of ten students for approximately 90 minutes per school day from September through June. No instructional aides were present in the classroom. The teacher had a bachelor's degree in psychology that emphasized applied behavior analysis, a master's degree in special education, and one year of part-time teaching experience.

The school provided 120 hours of professional development to all teachers prior to teaching. This training included sessions focused on the theory, practice, and delivery of generative instruction including Direct Instruction (Engelmann & Carnine, 1982), Precision Teaching (Binder, 1996; Johnson & Layng, 1992; Lindsley, 1991, 1995; White & Haring, 1980), Applied Behavior Analysis (Skinner, 1938; Vargas, 2009), instructional design (Markle, 1990; Skinner, 1968; Tiemann & Markle, 1991), classroom behavior management models and strategies (Colvin, 2004; Goldiamond, 1974, 1984; Latham, 1998; Paine, Radicchi, Rosellini, Deutchman, & Darch, 1983) as well as diagnostic tools that would be used as part of the RtI problem solving process. The teacher also received 15 hours of professional development training related specifically to the math curricula and assessment system. Finally, the teacher participated in a two hour faculty seminar each week throughout the school year focused on curriculum needs, instructional delivery, and sharing student Standard Celeration Charts to facilitate instructional decisions.

Students participated in a general problem solving and reasoning class for 30 minutes per day in addition to their 90-minute math class each day. The classroom was configured with one instructional white board in the front of the classroom and one instructional white board in the back of the classroom. Desks were arranged in a horseshoe around each instructional board with seating for 10 around the board in the front of the classroom and seating for four around the white board in the back of the classroom.

In the problem solving and reasoning class, the entire class received a 10-15 minute lesson focused on a critical component of the problem solving process or introducing a new type of problem using a program called Talk Aloud Problem Solving, or TAPS (Robbins, 1996, 2011, 2014). Next, students worked in pairs to solve problems provided by the teacher on worksheets. The TAPS program enabled students to develop two repertoires, becoming both a Problem Solver and an Active Listener, while using increasingly difficult content-free logic problems that made the talk aloud process more probable. Having a positive attitude, breaking a problem into parts, working carefully, following along like a teacher, checking for mistakes, and answering with confidence were all key competencies of the TAPS program.

In the math class, students were divided into two instructional groups using initial learning rate on various math skills, displayed on the Standard Celeration Chart, to classify students as fast or slow responders. This classification was used to create two instructional groups within the math class: Group A (6 students) and Group B (4 students). Group A comprised learners that demonstrated faster learning rates on the (1) Standard Celeration Charts, (2) CBM math computation, and (3) CBM concepts and applications charts during the first month (baseline period) of the school year.

As illustrated by the class schedule in Table 2, Group A (n=6) received a 10-15 minute *Saxon Math* lesson (in the front of the classroom) while Group B (n=4) practiced their skills using frequency building exercises in math computation (in the back of the classroom). Saxon math lessons were delivered using Direct Instruction methods that included choral responding and individual student responding to check for understanding of the lesson. If students answered incorrectly during choral responding, additional example/non-example sets were included until all students answered correctly. After Group A started to work independently on the Saxon Problem Set assigned for the day, the teacher went to the back of the classroom to deliver a 10-15 minute Saxon lesson to Group B. It is important to note that during both lessons, the teacher was giving explicit and frequent positive feedback to the distant group for staying on task and following directions. Contingencies were also established such that groups that stayed on task throughout the class and completed all work would have a 10 minute break at the end of the class period.

Using their personal timers, students tracked the total amount of time required to complete the *Saxon Problem Set*. Next, they were expected to self-correct the assignment using one of the answer keys provided by the teacher. Students recorded the total amount of time required to complete the assignment and the total number of errors on the top of their paper. The teacher would quickly review the mistakes made across instructional groups at the end of each class to evaluate the need for additional instruction on certain concepts the following day.

Table 2. Example of Daily Math Schedule

9:20 - 9:30	TAPS - Whole Group Instruction	
9:30 - 9:50	TAPS Practice (Partnered Practice)	
9:50 - 10:00	Break	
<u>Group A (= 6 students)</u>		<u>Group B (= 4 students)</u>
10:00 - 10:15	Saxon 54 Instruction - Lesson 1	+/- Math Fact Fluency
10:15 - 10:30	Saxon 54 Problem Set 1	x/* Math Fact Practice
10:30 - 10:45	Saxon 54 Problem Set 1	DP Math Computation
10:45 - 10:50	Break	Break
10:50 - 11:05	+/- Math Fact Fluency	Saxon 54 Instruction - Lesson 1-2
11:05 - 11:20	x/* Math Fact Practice	Saxon 54 Problem Set 2
11:20 - 11:35	DP Math Computation	Saxon 54 Problem Set 2
11:35 - 11:45	Break	Break

Note. TAPS = Talk Aloud Problem Solving.

In addition to the *Saxon Math* lesson and *Problem Set*, students spent time developing frequency-based mastery on three math computation skills each day including addition/subtraction math facts, multiplication/division math facts, and complex math problems. First students practiced attaining mastery on single digit math facts. There were 20 objectives included in the addition/subtraction math program (Morningside Press, 1993a) and 20 objectives included in the multiplication/division math program (Morningside Press, 1993b). Both programs were similar in that each practice sheet contained 100 math problems that required memorizing number families while including intermittent cumulative review slices. Students were expected to complete one duration timing in which they answered all the items on the page and then recorded the total amount of time required to complete the slice. Next, students were expected to complete at least three one-minute timings and chart the best performance of the day on the Standard Celeration Chart for that objective. In all timings, the goal was to beat the previous day's performance. Math Fact mastery was defined as writing 60 correct digits in one minute with no mistakes. Students that demonstrated mastery received a star on the related wall chart posted in the classroom and were allowed to progress to the next, more difficult objective of the program.

Students also practiced systematically building fluency in more complex math computation skills using an adaptation of the Precision Teaching based program referred to as *Diagnostic/Prescriptive Math Computation*, or DP Math (Morningside Press, 2000a, 2000b). The program was designed to "fast track" students through mastery of arithmetic skills. Using this program, each student's performance was assessed (diagnosed) and then instructed (prescribed) in deficient skills. Students completed an assessment that measures performance across 100 instructional objectives in addition, subtraction, multiplication, division, fractions, decimals, and calculating simple percentages. After the DP tests were administered, the teacher analyzed error patterns, distinguishing between operation and fact errors. The DP wall chart was then populated by the teacher and posted in the classroom. It showed the com-

plex math operations that each student had mastered, needed to practice, or needed to receive instruction on. In this way, the wall chart functioned as an individualized road map. Students could check the chart to determine which skills they needed to master next. Consequently, one student may be working on mastering long division with a two-digit divisor while another seated nearby worked on mastering dividing with decimals. The teacher provided brief instruction to individual students or in small groups as needed based upon their deficiencies. Similar to the math fact programs, students were expected to complete one duration timing and three one-minute timings each day on a specific DP math skill until fluency was achieved. Students were also expected to immediately self-correct their work using the answer key provided by the teacher. Mastery on a DP Math objective was defined as 60 correct digits written in one minute.

It is important to note that a group contingency system was utilized with each wall chart (addition/subtraction facts, multiplication/division facts, and DP math) such that each time the class achieved a set of 30 new mastery stars on any program (i.e., addition/subtraction math facts), the class received a reward such as a 15 minute class game, extra recess outside, or popcorn party. The reward was decided by the group beforehand and used as part of a larger incentive program to increase student motivation. After reaching the first reward level, students suggested and voted on the next group incentive for that particular wall chart. This contingency system resulted in more of a team-oriented atmosphere with peers consistently cheering for another's accomplishment in the math program.

Fidelity Assurance

The school's Executive Director, Principal, or Director of Assessment observed the teacher for a minimum of 30 minutes every other month and provided immediate feedback on implementation. The treatment fidelity checklist used to evaluate instruction is provided in Appendix A. Fidelity was determined to be above 90% across observations. Additionally, the teacher video recorded one instructional sequence (range, 10-15 minutes) twice during the school year. The recordings were shared and discussed with peers during the weekly staff seminar. Finally, the School Principal reviewed Meta Level data from the MBSP program with the teacher one time each month for approximately 5-10 minutes. If it was determined that a student was not making sufficient growth over time on a particular math computation component skill, the teacher designed a Precision Teaching based intervention to address the stagnant skill set.

Outcomes

Student performance from the *Iowa Test of Basic Skills* (ITBS) is summarized below in Table 3. Because *ITBS* test results were determined to most closely represent improvement in critical *composite math skills*, they are indicative of the general effects of the generative classroom. In fact, of the various components of the Multi-Level Assessment System, the ITBS could arguably be considered the least sensitive measure of growth for students functioning below grade level due to the large skill improvements needed to produce measurable change in ITBS scores upon re-testing with parallel alternate forms (Malmquist, 2004; Marston, 1989;).

Table 3. Mean Pre/Post ITBS Scores.

ITBS Subtest	Pre SS	Post SS	SS Diff	Pre GE	Post GE	GE Diff	Pre PR	Post PR	PR Diff
Concepts & Estimation	187.6	216.4	28.8	4.0	6.1	+2.1 years	35.1%	59.6%	24.4
Problem Solving	189.4	223.4	34.0	4.1	6.6	+2.5 years	36.6%	63.9%	27.3
Computation	176.7	236.9	60.2	3.5	7.9	+4.5 years	19.2%	83.2%	64.0
Math Total	184.0	224.8	40.8	3.8	6.5	+2.7 years	25.8%	66.6%	40.8

Note. N=10 students. SS = Standard Score, GE = Grade Equivalent, PR = Percentile Rank; Diff = Difference.

As depicted in Table 3, the mean pre-test Standard Score for ITBS Math Total was 184.0 while the mean post-test Standard Score was 224.8, representing a shift of +40.8 Standard Score points. Additionally, the mean pre-test Grade Equivalent score for the ITBS Math Total was 3.8 while the mean post-test Grade Equivalent score was 6.5. This reflects an average of +2.7 grade level gains in one academic year. When examining student performance in terms of Percentile Ranks, the mean pre-test Percentile Rank score for the ITBS Math Total was 25.8, while the mean post-test Percentile Rank score was 66.6, reflecting a shift of +40.8 percentile points on average in one academic year. Similar gains for Concepts and Estimation, Problem Solving, and Computation subtests were observed.

A summary of the effects of the math intervention in terms of grade level performance for students in this case study is provided in Table 4. As indicated below, only two of the ten students in the group received ITBS Math Total Scores commensurate with their grade level at the baseline measurement period (i.e., pre-test). Seven of the ten students had Math Total Grade Equivalent scores that were more than one year below their chronological grade level, with Percentile Rank scores below the 21st Percentile. One student performed in the low average range (39th percentile). The remaining two students in the group scored in the average range of performance when compared to typical, same-age peers upon initial testing. In contrast, all ten students were performing at grade level at the post-test for Total Math. Only one student post tested below grade level on a single subtest, Concepts and Estimation, whereas eight tested below grade level for that subtest on the pre-test. The range of ITBS Math Total post-test scores was between the 35th-85th percentile *for all ten students*, with one student performing in the low average range (35th percentile), five students in the average range of performance (i.e., between the 46th-69th percentile), and four students receiving scores in the above average range (>75th percentile).

Table 4. Number of Students Performing at Grade Level as Measured by the ITBS

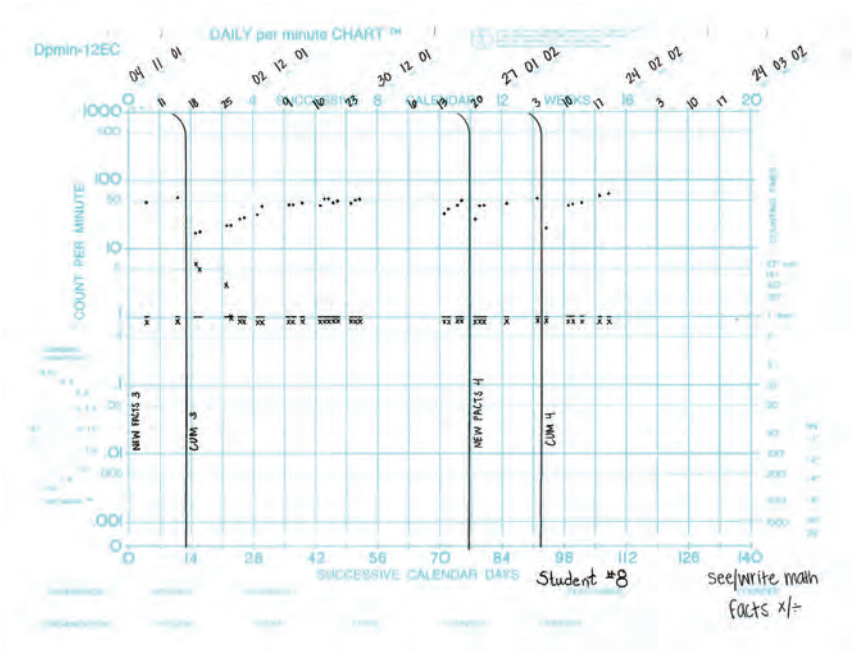
Subtest	Pre-Test	Post-Test
Concepts & Estimation	n = 2	n = 9
Problem Solving	n = 5	n = 10
Computation	n = 1	n = 10
Math Total	n = 2	n = 10

Note. N = 10 students.

Case Summary

The outcomes obtained in this case study suggested significant skill improvement was attained by all of the students who received this classroom implementation. Each student demonstrated steady, accelerated rates of improvement in the essential component skills of math. These effects were examined closely with daily (i.e., Micro Level) and weekly (i.e., Meta Level) measurement systems that informed instructional decision-making. An example of Micro Level data, representing Precision Teaching component skill mastery, is shown in Figure 3.

Figure 3. Precision Teaching Micro Level Data for “Student 8”



Perhaps most importantly, the ITBS results also indicated that the component skill mastery attained resulted in the students acquiring composite skill repertoires that could be reliably and validly detected using a group administered achievement test. The ITBS assesses a larger set of composite math skills including more

complex computation skills, math concepts and estimation skills, and problem solving than those directly taught during instruction. For some students, their success was also likely impacted by the increased rate of academic engagement they demonstrated relative to previous learning environments. All of the students included in this case study entered the school year with a long history of behavior, attention, and/or other learning difficulties and had not mastered many of the critical learning skills necessary for school success (e.g., time management, asking for help when needed, working independently, peer tutoring).

One thing the students in the present case study had in common was a lengthy history of school failure, characterized by instructional approaches that failed to address their academic and social needs. With the mixture of instructional elements described in this paper, including Precision Teaching and the use of a Multi-Level Assessment System, these students effectively doubled the rate of growth that would be expected for an “average” elementary or middle school student. The students included here were not making progress at a rate similar to their typical peers in their previous school settings, so this generative instructional methodology appears to have led to meaningful and significant academic gains, helping to close the gap between their performance and that of their peers.

Several limitations were inherent in the present study. First, this was intended as a descriptive case study taken from an actual implementation of Precision Teaching in an applied setting. Because of this practitioner focus, there was no experimental design implemented to help control for extraneous effects. The small sample size should clearly be taken into consideration when interpreting results as well. Thus, a more conservative approach would be to conclude that the ITBS results suggest a correlational relationship between the instructional intervention program and the outcomes achieved. Despite these limitations, this data set has great value in helping to illustrate the application of a successful MTSS model. These results also bolster the robust database that exists to date in support of instructional techniques rooted in the principles of applied behavior analysis. Yet, this specific blend of instruction is unique in that it involved a central focus on Precision Teaching within a generative framework while using Precision Teaching data to enrich the decision-making model.

Research to Practice

The teaching methodology described in this paper addresses many of the critical barriers that inhibit the adoption of RtI and MTSS frameworks designed to meet the needs of all students. It draws upon a rich research base of empirically validated instruction and measurement techniques, but offers the unique advantage of being designed with ease of implementation in mind. Despite research supporting its use and theoretical foundation, this level of intensive instruction and detailed analysis of student learning on a day-to-day basis is the exception, not the rule. Further studies examining the barriers that limit the adoption of appropriately intensive instruction are warranted. It is also important to note that, to the detriment of many of our most vulnerable learners, there appears to be a high degree of variability in what is viewed as “intensive” instruction in educational practice.

One of the goals of the present paper was to describe some of the features that must be present for students to achieve skill mastery, such that retention and

application of new skills occurs and leads to more complex learning and success over time. This detailed programming for retention and application of component skills is a hallmark of generative instruction and provides the closest match we know of to the unique challenges that children with special education needs may face. In fact, it could be argued that these techniques offer the most thorough approach to what we think of as “learning” because the conceptual underpinnings of learning are broken down into smaller chunks so that systematic mastery of the larger skills can be obtained.

CONCLUSION

A primary goal in presenting this case study was to describe a solution to a pervasive problem that exists in educational practice today – the adoption of a teaching approach that is characterized by an attempt to “teach” the composite skills a student must learn directly, out of order, and regardless of the specific entering skill proficiency of the student because the composite skill is the terminal objective for that particular grade level (i.e., aligns with the Common Core State Standards). This approach is often characterized by “exposing” students to instruction and then moving to the next lesson either regardless of mastery or otherwise assuming that if the student answers a specific problem type with 80-100% accuracy at one point in time, that mastery was achieved. While this may make sense from the perspective that, yes, we do want the child to ultimately master the higher-order composite skills, we believe this approach ultimately short circuits the learning process.

One of the most critical elements in the instructional program presented in this case study was the use of rate-based criteria to establish mastery in math computation skills, which requires accurate *and* fluent performance. Specifically, students practiced building fluency in sequentially ordered math computation component skills to a rate of 60 correct digits written in one minute before progressing on to the next more difficult skill. However, just as the skill of “learning to read” is not complete after mastering phonemic awareness and decoding, competency in math cannot be viewed as simply becoming proficient in number sense or math fact fluency. Yet, at the same time, it is dangerous to assume that these foundational skills are not crucial component skills that form the building blocks of the more complex skill repertoires. For instance, we do not consider a student who has difficulty with algebra to have an “algebra disability.” Rather, we find that *in every instance* in which students struggle with certain higher order math competencies, it is due to dysfluency in one or more of the essential component skills of that skill domain.

In closing, it is important to consider a related developing cultural problem we now face as well. Teachers and parents appear to be “rebellious” against “standardized testing” and “the common core” in alarming numbers (Eng, 2012; Lahey, 2014). Rather than suggesting we abandon sound assessment practices and empirically validated goal setting in education, we ought to view this problem as an unintended side effect of the instructional mismatch that may be built into current educational practice. Therefore, progress in achieving educational equality will require better alignment of our stated values with our practice.

It should be assumed that providing a free, appropriate public education for all children strengthens the U.S. as a nation, as it does any culture or society that

adopts a similar priority. However, this has turned out to be a daunting task. Because of the challenges inherent in such an undertaking, many reasons why we have fallen short of this goal have been proposed. In studying trends in educational practice over the last few decades, it is clear that more emphasis is needed relative to the quality and intensity of daily instructional delivery for at risk learners. While continued attention on the adequacy of learning standards (e.g., Common Core State Standards) is certainly warranted, any viable solution for truly meeting the unique academic needs of all students must go further and involve a careful examination of the very specific details of our teaching methodology and the manner in which we assess progress. The good news is that the solution to these challenges has never been closer. The progress that has been made in determining what works could be considered one of our greatest achievements of the past 100 years. The discoveries that have been made in the fields of learning and neuroscience are now at our fingertips. The challenge we are left with is determining the best way to get truly effective, empirically validated instructional programs and methods into the hands of those who need them.

Fortunately, instructional technologies are available that offer what is likely the best solution we have found to date for these complex problems; and, they are predicated on the extensive knowledge we have of learning and behavioral science. Including and further evaluating techniques derived from Precision Teaching, generative instruction, and a Multi-Level Assessment System within RtI instructional delivery models could help bolster MTSS frameworks and revolutionize the education of struggling students. It is only when we close the gap between our collective knowledge of how to provide a free, appropriate education for all learners and our ability to implement these strategies effectively in our nation's schools for all children, regardless of race, disability, and socioeconomic status, that our mission will be complete.

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APPENDIX A. TREATMENT INTEGRITY CHECKLIST

Date: _____

Name: _____

Coach: _____

General Coaching Form

Organization			
yes	no		All materials needed ready
yes	no		Materials accessible to students
yes	no		Seating allowed for visual of all students
yes	no		Daily schedule posted and lists all parts of lesson
Getting Started			
yes	no	n/a	Teacher checked in with student displaying possible problem
yes	no		Students knew what to do when they enter classroom
yes	no		Instruction started within 2-4 minutes
Expectations			
yes	no		Attention signal delivered before instruction. Type:
yes	no		Students had group response to signal
yes	no		Teacher voice was bold and displays confidence
yes	no		Teacher language was concise
yes	no		Expectations/Corrections stated in Can-do phrases (not don'ts)
yes	no		Expectations given at appropriate junctures. # of times? When?
Instruction			
yes	no		Pacing was energetic and appropriate
yes	no		Used group responding for 1-2 word answers
yes	no		Highly Interactive - How?
yes	no		Demonstrated or modeled appropriately
yes	no		Prompted or guided appropriately
yes	no		Released to individual practice appropriately
yes	no		Used examples and non-examples
yes	no		Gave timely and specific feedback
yes	no		Catched all errors. Types of errors:
yes	no		Provided no inadvertent cueing or ceilings
yes	no		Provided instruction to at least two instructional groups. How many?
Practice			
yes	no		Teacher decision to practice was appropriate
yes	no		Students started within 2 minutes
yes	no		Students displayed appropriate behavior
yes	no		Students were continually engaged
yes	no		Appropriate interventions made as needed
yes	no		Teacher constantly scanned and circulated
yes	no		Students knew what to do when finished
Behavior Management			
yes	no		Praise was immediate and specific
yes	no		Teacher maintained adult calm
yes	no		Displayed genuine empathy & interest
yes	no		Acknowledged student cooperation
yes	no		Anticipated problem behavior and responded
yes	no		Acted urgently given safety issues
yes	no		Transitions were clear and quick
yes	no		Had long term rewards system in place
yes	no		Had short term rewards system in place
			Used: Social ___ Tangible ___ Activity ___ Token ___ Edible ___