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USING CURRICULUM-BASED MEASUREMENT TO IMPROVE STUDENT ACHIEVEMENT: REVIEW OF RESEARCH

PAMELA M. STECKER

Clemson University

LYNN S. FUCHS AND DOUGLAS FUCHS

Peabody College of Vanderbilt University

This review examines the efficacy of curriculum-based measurement (CBM) as an assessment methodology for enhancing student achievement. We describe experimental-contrast studies in reading and mathematics in which teachers used CBM to monitor student progress and to make instructional decisions. Overall, teachers' use of CBM produced significant gains in student achievement; however, several critical variables appeared to be associated with enhanced achievement for students with disabilities: teachers' use of systematic data-based decision rules, skills analysis feedback, and instructional recommendations for making program modifications. In general education, positive effects for CBM were associated with use of class profiles and implementation of peer-assisted learning strategies. Implications for instructional practice and future applications of CBM are described.

An increasingly popular form of alternative assessment, known as curriculum-based measurement (CBM), is used by teachers and school psychologists for monitoring student progress. The roots of CBM lay with the University of Minnesota's Institute for Research on Learning Disabilities (IRLD) in the mid- to late 1970s during the time of the original passage and implementation of the Individuals with Disabilities Education Act (IDEA), known then as Public Law 94–142. Stan Deno and colleagues sought to develop a simple and efficient, but technically adequate, measurement system for assisting special educators in tracking student growth in basic skills (for review, see Deno, 1985). Deno and colleagues designed a program of research to determine the technical features of CBM and to examine the utility of CBM for enhancing teachers' instructional planning and student learning. Consequently, the initial purpose for developing CBM was to assist special educators in using progress-monitoring data to make meaningful decisions about student progress and to improve the quality of instructional programs. Over the past 25 years, numerous investigations have emerged that utilized CBM in a variety of ways including, but not limited to: (a) establishing norms for screening and identifying students in need of special education services (Shinn, 1989b), (b) evaluating the effectiveness of educational programs (Tindal, 1992), (c) reintegrating students with disabilities into general education classrooms (D. Fuchs, Fernstrom, Reeder, Bowers, & Gilman, 1992), (d) monitoring progress and planning instruction within general education classrooms (L.S. Fuchs, Fuchs, Hamlett, Phillips, & Bentz, 1994), and (e) identifying potential candidates for special education evaluation using a dual-discrepancy model of low level of performance and inadequate rate of improvement (L.S. Fuchs, Fuchs, & Speece, 2002).

Despite the various ways in which CBM has been applied, the original intent was for teachers to use technically sound, but simple, data in a meaningful fashion to document student growth and determine the necessity for modifying instructional programs. The hope was that by responding instructionally to students' poor patterns of performance, teachers should be able to enhance student achievement. Early research conducted through the IRLD found mixed results regarding the effects of CBM on student achievement. Several studies failed to produce significant achievement gains among students with disabilities when teachers monitored progress with CBM (King,

Correspondence to: Pamela M. Stecker, Clemson University, Clemson, SC 29634. E-mail: stecker@clemson.edu

Deno, Mirkin, & Wesson, 1983; Skiba, Wesson, & Deno, 1982; Tindal, Fuchs, Christenson, Mirkin, & Deno, 1981); however, researchers reported that although experimental teachers collected CBM data accurately, they neglected to comply with standard data-utilization procedures. That is, few instructional changes were made when the data indicated a need for modification. In contrast, L.S. Fuchs, Deno, and Mirkin (1984) conducted a large-scale investigation with 39 special educators in New York City who either used CBM to monitor student performance and adjust instruction or did not use CBM. They found significant effects for CBM implementation on student achievement in reading. At the same time, despite documentation that CBM could be used to effect better student outcomes, Wesson, King, and Deno (1984) reported that some teachers elected not to use CBM due to dissatisfaction with its time-consuming nature.

Therefore, the purpose of this review is to examine factors that appear to affect the efficacy and feasibility for using CBM to promote student achievement. First, we illustrate general procedures for conducting CBM in both reading and mathematics. Then, we review a program of research in CBM that examined factors associated with improved student achievement. Group-design studies that contrasted CBM (or more than one variation of CBM) with a traditional, comparison group are summarized for students with mild to moderate disabilities. For investigations with significant effects, we explicate factors that may affect the utility and feasibility of CBM implementation. We also describe the use of CBM in general education classrooms for enhancing student achievement of students both with and without disabilities. Finally, we suggest future directions for CBM applications.

Overview of CBM

CBM relies upon several distinguishing features. First, CBM assesses student progress toward long-term goals. That is, evaluation of general outcomes rather than mastery of successive objectives is a primary distinction of CBM. In fact, L.S. Fuchs and Deno (1991) referred to CBM as *general outcome measurement*. For example, with CBM, alternate forms of short tests are developed that sample performance toward the long-term goal, not just the content or skills the student is learning currently. Performance on these measures illustrates what a student is able to do relative to the long-term goal, or general outcome. For example, L.S. Fuchs and Deno (1992, 1994) found that monitoring the student's own curricular materials was not necessary for meeting technical adequacy or for utilizing CBM procedures appropriately and successfully. Teachers could use story passages from outside the student's curriculum and still use CBM information effectively to monitor student progress in reading and to make instructional decisions. Overall improvement in reading on a variety of grade-appropriate materials is noted as the general outcome, not just successful reading of particular passages within a student's curriculum. Thus, a major component of CBM procedures involves the determination of the pool of items or content that reflects the general outcome.

A second important feature of CBM is frequent monitoring and graphical depiction of student scores for decision making; students typically are assessed once or twice weekly with scores plotted on a time-series, equal-interval graph. Consequently, CBM encompasses formative assessment, as data reflect how a student performs over a period of time. Because the content or level of difficulty of the measures and the time allotted for the assessment tasks remain constant, student change in performance can be compared across time. Teachers then use graphed data to judge whether students are progressing at satisfactory rates and levels to meet intended outcomes by particular points in time. In other words, CBM is used in predictive fashion to estimate whether students are on target toward meeting long-term goals; however, data also are used to judge relative current performance and to determine whether the most recent instructional program has been effective in bringing about student growth. This judgment is particularly important in special education because CBM data help teachers to plan and individualize instruction (i.e., tailor instruction to meet individual student's needs).

A third, critical feature of CBM is its documented technical adequacy. Utilizing measures that are technically sound is an important aspect of any assessment methodology used to make decisions about student performance. Research has validated the use of CBM procedures for assessing ongoing student progress and for making instructional decisions (see Shinn, 1989a). Procedures have been prescribed for elementary-level content and have been applied to several academic domains such as reading, spelling, written expression, mathematics computation, and mathematical concepts and applications. More recent work has extended CBM procedures upward to encompass secondary content (e.g., Busch, & Espin, 2003; Espin & Tindal, 1998), and a variant of CBM extends evaluation downward to assess discrete early literacy skills (Kaminski & Good, 1998). General CBM assessment procedures remain the same even when the specific content or curriculum varies. Within each academic domain, equivalent forms are used so teachers can determine whether student performance changes over time. Using aggregated data across multiple assessments also reduces measurement error and allows the teacher to judge whether the student appears to be on track toward attaining the long-term goal as well as to make decisions appropriately about the efficacy of the current instructional program.

Next, we describe specific applications of CBM in reading and mathematics. The development of measures, scoring conventions, goal setting, and progress-monitoring decisions are included in these descriptions.

Application in Reading

For CBM in reading, the most commonly used general outcome is proficient oral reading. Although several measures were studied by researchers at the IRLD, the number of words read correctly in a 1-min oral reading sample of curricular material generated a reliable and valid indicator of overall student reading proficiency (Deno, Mirkin, & Chiang, 1982; L.S. Fuchs, Fuchs, & Maxwell, 1988; Marston, 1989). Typically, passages are selected that represent the instructional grade level for student mastery by the end of the year. These selections do not need to be derived from the student's own curriculum, as oral reading fluency on measures that have not been practiced previously reflects generalized student performance and still is sensitive to student change. Teachers usually assess oral reading fluency once or twice weekly. Scoring conventions require that teachers tally the number of words read correctly in 1 min. Teachers supply the word for a hesitation that lasts 3 s, but count the word as incorrect. Self-corrections provided within 3 s are counted as correct. Mispronunciations, substitutions, omissions, and transpositions are considered to be errors. Insertions and repetitions are ignored. The total number of words read correctly is plotted on a graph. The median of several data points provides an estimate of baseline performance. Teachers set year-end goals by adding to baseline performance the product of typical or ambitious weekly growth rates (see Deno, Fuchs, Marston, & Shin, 2001; L.S. Fuchs, Fuchs, Hamlett, Walz, & Germann, 1993) and the number of weeks left to the end of the year. Alternatively, teachers may consider desirable reading rates for students of different grade levels (see Carnine, Silbert, Kame'enui, & Tarver, 2004) when establishing long-term goals. Once baseline performance and the desired goal have been established, a line is drawn on the graph connecting these points. This goal line represents the anticipated growth rate across the year for goal attainment. When monitoring twice weekly, teachers may examine student performance and compare it against the goal line (i.e., student's expected rate of progress) approximately every 3 to 4 weeks. If the student's trend of current performance is less steep than the goal line or if the student's most recent 4 consecutive data points all fall below the goal line, an instructional program change is warranted. If the trend of current performance is steeper than the goal line or if the last 4 consecutive data points all fall above the goal line, then raising the year-end goal is an appropriate decision. In this manner, a student's progress is evaluated regularly, and teachers respond to poor patterns of growth by making instructional changes in an effort to stimulate better performance.

Later, as CBM included computer applications, the maze measure was documented as a reliable, valid indicator of reading achievement, much like oral reading fluency (L.S. Fuchs, Fuchs, Hamlett, & Ferguson, 1992). With the maze task, a grade-level passage is provided that represents the level expected for mastery by year's end. The first and last sentences of the passage are left intact, but approximately every seventh word is deleted from the rest of the passage. Three word choices are provided for each blank, and the student selects the correct word. The measure is timed (i.e., lengthened from 1 min used with oral reading fluency to $2\frac{1}{2}$ min for the maze task due to improved technical adequacy for this more restricted range of correct responses), and the score on the graph represents the total number of correct maze choices. As students develop better reading skills, they are able to read farther in the passage and select correctly more words for the blanks. Data utilization and decision making follow the same procedures as with oral reading fluency.

Application in Mathematics

In addition to reading, we also address mathematics in this article. Two reasons suggest the need for focus on both academic areas. First, students with disabilities frequently demonstrate poor achievement in both areas. Second, although CBM progress-monitoring techniques in both reading and mathematics yield estimates of student progress toward long-range goals, the method of sampling student performance in these two domains has been applied in different ways. Because mathematics generally is accepted as more skill specific than reading, content for CBM mathematics tests is derived by determining the grade-level skills deemed important in the student's curriculum. The general outcome typically is described as proficiency across these critical, grade-level skills.

Although mathematics was not investigated originally as a part of the IRLD, Shinn (1989a) described general procedures for developing CBM assessments of basic computational facts for single-skill tests or simple sets of mixed computational skills by grade level. In the mid- to late 1980s, work at Peabody/Vanderbilt addressed content for mathematics as mixed-problem formats that represented skills regarded as most important for mastery at each grade level according to state-level tests that were administered at each grade (see L.S. Fuchs, Fuchs, Hamlett, & Stecker, 1990). Consequently, CBM assessments were developed that represented the most critical computational skills at each grade level. Twenty-five problems were generated for each measure, and problem types were represented in similar proportion to their importance in the state-level curriculum. Each grade-level, alternate form comprised the same problem types in the same proportion, but used different numerals. Problems were assigned in random order on the page, and students were instructed to begin with the first item and to complete it if possible and then move to the next item. Students were told that they could attempt a problem even if they did not think they could get the entire answer correct because they would be given partial credit for any part of the answer that was correct. Each digit in the answer was scored as correct as long as it was the correct numeral in the right place (i.e., consideration was given to place value). The total number of correct digits in answers was a more sensitive index of student change than number of problems correct, so digits correct became the datum plotted on the student's graph (L.S. Fuchs et al., 1990). The same data-utilization rules and decision-making processes were applied to mathematics as were used in reading.

Likewise, student progress could be monitored in mathematics concepts and applications (L.S. Fuchs, Fuchs, Hamlett, Thompson, et al., 1994). Assessments were developed in similar fashion to the computational measures with problems representing critical, grade-level skills in conceptual knowledge/understanding and applications. For example, depending on the grade level, assessments may have included items pertaining to money, measurement, word problems, graphs/charts, and geometry. The same problem types were used for each alternate form, and student performance was depicted by the number of points correct in the student's answers. Points were used instead of digits because some items involved selection of the correct answer, such as choosing a line, ray, or line segment, rather than computing answers that contained digits; however, most problems required a numerical response, and one point was assigned to each digit correct in the answer.

Enhancing Achievement of Students with Disabilities in Reading and Mathematics

Beginning in the mid-1970s through the early 1990s, research on CBM focused on students with disabilities and examined whether use of CBM-aided instructional decisions produced differential achievement among students. Thus, in the following sections, we describe this research for experimental-contrast studies with students with mild to moderate disabilities. To evaluate achievement effects, only studies utilizing a pretest–posttest design for at least one achievement measure are included in this brief synthesis. Other substantive features include twice-weekly data collection, teachers' use of data for instructional decision making, and a treatment period of at least 7 weeks. If utilizing standard data-decision rules, 7 weeks comprised the minimum amount of time necessary to conduct baseline data collection, to implement and evaluate the effects of one instructional program, and then to implement and evaluate the effects of an alternative (i.e., second) instructional program if student data indicated the need for instructional modification. Because many of the CBM studies evolved from a program of research that incorporated procedures used previously or included variables found to be significant in earlier research, we present these studies in chronological order. We also group the studies by variables that appeared to affect feasibility and utility. First, we describe studies that incorporated data-based decision rules. Then, we discuss studies in which skills-analysis feedback about student performance was provided to teachers. Finally, we describe studies that also included the provision of instructional recommendations when making program modifications. Following this discussion of studies that focused on results for students with disabilities, we describe selected studies conducted in general education classrooms that focused on the addition of peer-mediated strategies to the CBM progress-monitoring system.

Data-Based Decision Rules

Studies without achievement effects. Tindal et al. (1981) examined 20 special educators' use of progress monitoring for 4 to 6 students each toward either long- or short-term reading goals. Teachers monitored daily, weekly, or just on a pretest–posttest basis during the 12-week intervention period. Teachers used 25-item word recognition tasks for monitoring student performance. Words used for monitoring short-term goals were drawn from current and previously read instructional stories. Words used for monitoring long-term goals were drawn from a larger pool of vocabulary words introduced across the 12-week intervention. Teachers were expected to review data frequently and to judge when to make instructional changes. When progress was inadequate or following 10 days of instruction, teachers were expected to make a teaching change. Dependent measures consisted of isolated word lists randomly sampled across kindergarten through third grade and were administered at Weeks 1, 7, and 12. No statistical differences emerged among treatment groups. Researchers noted that the lack of effect for student achievement may have been due to poor implementation of the treatment; however, the descriptions of the treatment led the reader to question whether the interventions really differed substantially from each other or from the pretest–posttest contrast group. For example, the daily measurement group monitored performance on average only 3 days per week, thereby diminishing the difference between the daily and weekly measurement groups. Teachers failed to comply consistently with data-utilization rules in both the long- and short-term goal conditions. Even so, teachers were encouraged to make instructional programmatic changes every 2 weeks; however, the same teachers in the progress-monitoring treatment groups also taught students who were assigned to the pretest–posttest contrast condition. Consequently, these intended contrast students could have received treatments identical to their peers. How data actually contributed to teacher decision making remains unclear, and this study seems to suggest that engagement in measurement procedures alone was not enough to bring about student change.

In another study with disappointing results, Skiba et al. (1982) taught seven resource teachers to monitor the progress of elementary and intermediate students. Twenty experimental-contrast pairs participated, and one partner was monitored daily on 1-min oral reading samples taken from the student's curriculum. Teachers did not monitor the other partner's progress with CBM. Teachers were encouraged to evaluate student performance after every seventh datum and to make instructional changes when the trend of student progress was less steep than the goal line depicted on CBM graphs. Timed oral-reading samples on third-grade passages were administered early in treatment, at midyear, and at year's end. No significant differences were detected between the measurement–nonmeasurement pairs. Fidelity of treatment measures indicated that teachers complied with measurement procedures, but did not make instructional changes when warranted. In fact, teachers made only 1.4 teaching changes on average per experimental student across the year. Few instructional modifications were made in reading programs, and when they were made, changes were not timed in accordance with data-utilization rules. The researchers contended that failure to obtain significant achievement effects was due to teachers' poor evaluation of data and lack of compliance with data-utilization procedures; however, no information was provided about the instructional program for contrast partners. Consequently, one could speculate whether instructional programs for the pairs differed at all, thereby mitigating any effects program modifications may have had for experimental students.

A third study with similar limitations was conducted by researchers at the IRLD (King et al., 1983) and involved 38 students in Grades 1 to 6. Special educators monitored the reading progress of half of the students by utilizing oral-reading fluency conducted on a daily basis for 7 months. When student progress appeared less steep than the established CBM goal line, teachers were instructed to implement a teaching change. As with the two earlier studies, no differences were detected on oral-reading passages administered on three occasions during the year between the students monitored with CBM and the students whose progress was not monitored in an ongoing fashion; however, both groups of students did improve significantly in oral-reading fluency across the year. The researchers also reported that only 10 instructional modifications had been made across a 5-month period for 19 experimental students and that teachers did not adhere consistently to data-utilization rules. Because so little information was provided about the students, their performance, and their teachers' instructional modifications, the reason for lack of significant effects for the monitored group remains unclear. Nevertheless, given the results of all three experimental investigations, it appears that monitoring student progress alone does not enhance student achievement.

Studies with achievement effects. The first experimental study that detected significant achievement effects in reading for students whose teachers monitored progress using CBM was conducted by L.S. Fuchs et al. (1984). Thirty-nine special educators were assigned randomly to one of two groups: (a) a progress monitoring condition, called data-based program modification, in which teachers measured oral-reading fluency at least twice weekly, compared slope of progress for every 7 to 10 data points against the goal line, and made instructional modifications when slopes were less steep than the goal line or (b) a conventional special education evaluation condition in which teachers used their typical procedures for monitoring student progress and for adjusting programs. Teacher trainers met weekly with experimental teachers to assist with the CBM data-utilization procedures and with contrast teachers to discuss strategies for diagnosing and intervening with learning and behavior problems. At pre- and posttest, three 1-min timed readings on selected passages were administered; words correct and errors were tallied. In addition, four subtests of the Stanford Diagnostic Reading Test (Karlsen, Madden, & Gardner, 1976) were given at posttest. Because experimental students committed significantly more oral-reading errors at pretest, researchers covaried posttest reading scores with pretest errors. Analyses of covariance yielded significant effects for both oral reading and the norm-referenced reading subtests in favor of the students whose progress was monitored with CBM procedures. Although little information was provided about teacher adherence to data-utilization rules, perhaps the ongoing consultation with teacher trainers ensured compliance with CBM procedures; however, weekly meetings alone did not account for the significant effects because teacher trainers also met weekly with contrast teachers. In contrast to the earlier studies in which teachers' applications of the data-utilization rules were sporadic at best, use of the systematic procedures prescribed by CBM in the L.S. Fuchs et al. (1984) study appeared to affect student achievement positively and powerfully.

Similarly, Jones and Krouse (1988) reported a positive effect on reading achievement when they taught 12 student teachers to apply CBM reading procedures with students with learning disabilities in Grades 3 to 6 over an 8-week period. Twice weekly, student teachers monitored oral-reading fluency, vocabulary skills, and reading comprehension. Ten student teachers monitored mathematics computation. Additionally, supervisors met weekly with student teachers to discuss data and to provide feedback. In this condition, called data-based problem solving, student teachers were expected to make instructional changes when warranted. Conversely, 9 contrast student teachers in reading and 8 contrast student teachers in mathematics also received supervision and participated in feedback conferences; however, their supervisors never addressed student achievement directly. Researchers reported that students whose progress was monitored frequently improved significantly more than did contrast students from pre- to posttest on oral-reading fluency. In fact, an average gain of 13 words correct was achieved by the experimental students versus an average gain of three words correct for the contrast group. Researchers also reported a significant difference in favor of the experimental group for posttest-only, comprehension question-answering scores that were covaried with pretest oral-reading scores; however, due to inconsistencies with presentation of the data, it is difficult to conclude with certainty that achievement effects were exhibited with the comprehension measure. Seeming inconsistencies with data analysis also make it difficult to interpret mathematics results with confidence. The researchers reported no significant differences between the two groups on four computational measures; however, it is possible that sample size was too small to detect a truly significant effect because the experimental group grew almost 10 times more than did the contrast group from pre- to posttest. Although researchers did not specify data-utilization rules that were followed, experimental student teachers had to present their student data during weekly sessions with supervisors. Thus, the likelihood that these student teachers used data for their decision making is high. Consequently, this study lends support for the use of CBM data in modifying instructional practices and enhancing achievement of students with disabilities.

In the late 1980s, to address teacher concerns about the time needed to develop CBM tests, administer and score them, and graph and use the data (Wesson et al., 1984), Lynn and Doug Fuchs and colleagues explored computer applications to reduce the amount of time teachers invested in data-management tasks. Consequently, subsequent studies focused on various aspects of computer applications for CBM data management and implementation. In one early study, L.S. Fuchs, Fuchs, and Hamlett (1989b) assigned experimental teachers to one of two CBM groups or to a contrast group that use their own methods for progress monitoring. Half the CBM teachers administered and scored by hand either a reading recall or cloze measure twice weekly. The other CBM teachers employed software that automatically administered and scored these same progress-monitoring measures; however, all CBM teachers used a data-management program that graphed student scores and applied data-decision rules for every 7 to 10 data points. When no achievement effects were noted for type of monitoring measure used or for format for test administration, the researchers examined teachers' level of compliance with data-decision rules. Recognizing that some teachers had failed to introduce teaching changes even when prompted by the computer, researchers examined more closely the achievement of students whose teachers made at least one program modification and maintained it for a minimum of 2.5 weeks. Slopes of progress were significantly higher for those students whose teachers used the database formatively to develop instructional programs. The Reading Comprehension subtest of the Stanford Achievement Test (Gardner, Rudman, Karlsen, & Merwin, 1982) was given at posttest. Scores were covaried with a written retell measure given at pretest. Students whose teachers had implemented program changes during the year (i.e., used CBM for evaluation of instructional effectiveness and program modification) significantly outperformed the contrast group. Although means favored the CBM group whose teachers used data for instructional evaluation, the achievement of students whose teachers collected CBM data but who had implemented only one reading program throughout the year failed to differ significantly from either the (a) CBM plus evaluation group or (b) contrast group; however, the dependent measure was a commercial, standardized test. Perhaps use of a measure that more closely mirrored the content of instruction may have demonstrated greater sensitivity to treatment differences. Because this study examined teachers' use of student performance data for instructional decision making in retrospective fashion, results should be interpreted with caution. Nonetheless, this study also suggests that compliance with data-utilization procedures appears important for effecting student growth.

To examine the notion that employing data-based decision rules is a critical component of CBM procedures, L.S. Fuchs, Fuchs, and Hamlett (1989a) examined alternative data-utilization procedures with teachers who monitored progress in mathematics. Researchers randomly assigned 30 special educators to one of two CBM conditions (i.e., static goal vs. dynamic goal) or to a condition in which teachers used their own typical ways of monitoring student progress. CBM teachers administered alternate forms of grade-level computational measures twice weekly for 15 weeks. Data-management software stored and graphed student scores on the frequent measures and provided an analysis of student progress every 7 to 10 data points. All CBM teachers were instructed to set ambitious, but realistic, goals for their students. One group of teachers was assigned to a static-goal condition in which teachers were free to raise goals if student performance exceeded the slope of the goal line, but they were never instructed to do so. Conversely, CBM teachers assigned to a dynamic-goal condition were prompted to raise student goals when the rate of current student performance was steeper than the goal line. When teachers raised goals, the data-management program redrew a new goal line with its increased slope. Contrast teachers did not monitor student progress with CBM, but used their own typical methods for monitoring and adjusting programs. The Mathematics Computation Test (described in L.S. Fuchs et al., 1989a), a computational test of 36 problems reflecting important objectives across Grades 1 to 6, was given at pre- and posttest. Students in the dynamic-goal condition significantly outperformed students in the contrast condition on number of digits correct. Teachers in the dynamic-goal condition introduced significantly more goal changes than did teachers in the static-goal group.

Moreover, the goal ratio (i.e., the final goal divided by baseline median) was significantly higher for the dynamic group than for the static group. The authors concluded that the goal-raising feature was an important addition to the data-utilization procedures: Students whose teachers were prompted to raise goals performed better than contrast students. After examining the lack of goal-raising practices by CBM teachers who had not been prompted to raise goals when data patterns warranted it, the authors concluded that teachers may underestimate actual student progress and may fail to raise goals spontaneously when student patterns of performance yield faster rates of learning than those expected.

The researchers (L.S. Fuchs et al., 1989a), however, did not speculate why students in the dynamic-goal condition failed to outperform students in the static condition on the achievement measure or why students in the static condition failed to distinguish themselves from the contrast group. If teachers underestimated student performance and failed to raise goals spontaneously, one would expect teachers to keep programs relatively intact because student performance patterns would not indicate a frequent need for instructional modification. Without frequent programmatic changes, perhaps instruction in the static group mirrored that of conventional practice. The notion that few instructional modifications are implemented in typical special education practice has been supported by other work as well (e.g., L.S. Fuchs, Fuchs, & Stecker, 1989). When a goal is raised, however, the recalculated goal line represents a faster rate of anticipated progress—and greater likelihood that an instructional change eventually will be needed. Consequently, prompts for instructional changes could have occurred more frequently in the dynamic-goal condition. Perhaps the modifications of student programs contributed the most to overall achievement effects. The authors could have buttressed their conclusions if they had provided data indicating the number of instructional changes implemented by the two CBM treatment groups. Nevertheless, prompting teachers to raise goals when a student's actual progress exceeds the rate of anticipated progress became a standard feature of CBM procedures.

Summary of results for use of decision rules. Results from the experimental studies described thus far demonstrate that teachers' simple collection of CBM data may not be powerful enough to effect student achievement. Rather, teachers must use the database to evaluate their instructional effectiveness; when student progress is less than expected, teachers must make program modifications. Raising goals when teachers underestimate student performance also appears to affect student growth. Data-management software also emerged as an aid to teachers in their use of CBM. As data-management software was developed to assist teachers with tasks of graphing and data analysis, L.S. Fuchs, Fuchs, and Hamlett (1988) found that teachers complied better with CBM decision making. A tutorial routine was introduced with the software that explained the rationale for changing instructional programs or raising goals. Although more time was required by teachers to use the software, teachers reported greater satisfaction using the software than performing all management tasks by hand.

With further development, software incorporated student-data collection. That is, software generated, administered, and scored student tests as well as displayed results in graphic format for both students and teachers. L.S. Fuchs, Fuchs, Hamlett, Stecker, and Ferguson (1988) evaluated teacher efficiency and satisfaction of the additional computerized features. Ten special educators administered and scored tests by hand and used the computer for data-management purposes only. Another group of 10 special educators used the computer to administer and score tests as well as to manage data. Teachers who utilized software for automatic test administration as well as data management reported greater satisfaction with CBM procedures and spent substantially less time in CBM tasks than did teachers who performed test administration and scoring procedures by hand. Moreover, employing software to accomplish additional CBM tasks facilitated the training of teachers in the use of CBM. Thus, computers did in fact help teachers in the collection and management of CBM data as well as in the utilization of those data for instructional planning. Compliance with decision rules, though, necessitated that teachers make sound instructional modifications in student programs when warranted by CBM data. To help teachers address this problem, researchers continued to pursue work with computer applications.

Skills Analysis

With computerized data collection, both the total test scores and the actual student responses to individual test items can be saved. For example, in mathematics, an analysis of student answers could be provided. Because grade-level mathematics measures display the same types of problems in the same proportion on each alternate test form, student responses could be grouped by problem type. Consequently, a skills-analysis component was added to the software to enhance teachers' use of the CBM data for instructional decision making.

CBM and skills analysis used individually. To assess the value of this type of skill-analysis feedback, L.S. Fuchs et al. (1990) experimentally contrasted two versions of CBM with a contrast group of teachers not using CBM. One CBM condition had access to the skills-analysis component in addition to computerized CBM data collection and data management. Another group of teachers employed the CBM software for test administration and data management, but they did not have access to computerized skills-analysis information. With both CBM groups, software displayed student graphs and prompted teachers about instructional decision making, including the use of dynamic-goal setting. The skills-analysis group, however, also saw qualitative information in text and graphic format that summarized current student performance information as well as progress over time by level of mastery for each problem type on the CBM tasks. In Figure 1, both the CBM graph and skills-analysis information can be seen. The graph depicts the total number of digits correct in student answers across time, which both groups of CBM teachers were able to use. The skills analysis, seen by only one group of CBM teachers, shows the breakdown of particular problem types assessed on each measure by level of mastery for every 2-week time interval. Increasingly darker boxes indicate greater levels of mastery. For example, a box that is not blackened at all indicates that the student had not attempted that particular problem type over the 2-week period, and a completely blackened box indicates mastery for that skill. By examining the skills analysis and by identifying the problem types that have been taught, teachers can determine the skills on which students continue to experience difficulty as well as judge retention and generalization of skills across the year.

In the L.S. Fuchs et al. (1990) study, a mathematics-computation test incorporating skills from the statewide curriculum in Grades 1 to 6 was administered to all three groups of students on a pre- and posttest basis. Results indicated that the skills-analysis group outperformed the other two groups on digits correct. Problems correct also showed the same pattern, but results were not statistically significant. No differences between the two CBM groups were noted for number of student measurements, goal changes, or instructional modifications; however, performance of CBM students whose teachers did not have access to skills-analysis information did not differ from non-CBM students whose teachers used their own forms of assessment. This finding was surprising in view of previous work (see L.S. Fuchs et al., 1989a), but the authors posited that automatic data-collection techniques without skills analysis prevented teachers from having a routine way to inspect student responses on the CBM tasks. Conversely, the added skills-analysis component may have supplied the missing information needed for more specific instructional planning in the CBM skills-analysis group. Thus, the skills analysis may have aided teachers in targeting which types of mathematics problems to teach or reteach.

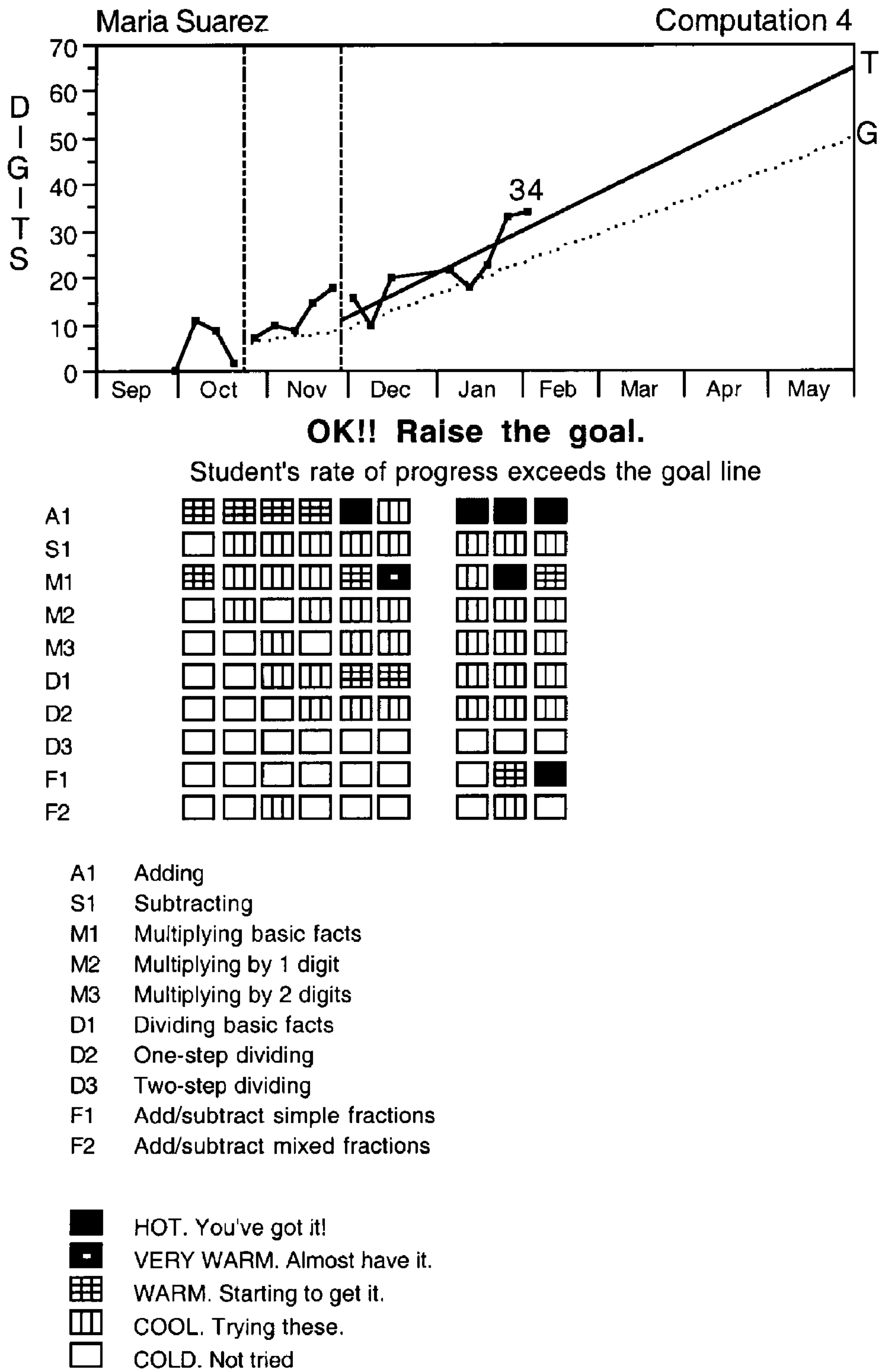

FIGURE 1. Student graph and skills analysis in mathematics computation.

CBM and skills analysis used for pairs of students. A second study examined use of the computational skills analysis in another way. Stecker and Fuchs (2000) questioned the importance of the timing and nature of instructional modifications. They sought to determine whether CBM data were essential for progress monitoring or whether teachers could effect similar achievement gains if they implemented programmatic changes on a regular basis. That is, researchers recognized that special education teachers implemented changes infrequently in their instructional routines; however, they noted that student achievement was enhanced when teachers responded to the CBM database by making modifications in instructional practice. That is, teachers modified instruction when student patterns of performance indicated inadequate progress towards meeting goals. Consequently, Stecker and Fuchs designed a study to evaluate the effect instructional changes have when timed and planned in conjunction with CBM data versus the same instructional changes being implemented with initially comparably performing students without the benefit of their CBM data. Special educators selected 2 comparably performing students, but agreed to monitor the progress of only 1 student in the pair with CBM and to make instructional changes when warranted by that student's CBM data for both students. In addition to the graphed total scores, teachers also had access to the skills analysis for students who were monitored with CBM. Thus, the overriding question pertained to the necessity of CBM data for evaluating student progress and for making instructional decisions.

Forty-two pairs of students with mild to moderate disabilities in Grades 2 to 8 participated in the study (Stecker & Fuchs, 2000). Students had goals in mathematics on their Individualized Educational Plans (IEPs) or functioned at least one-half grade level below expected mathematics level. Teachers also selected a partner for each student whose performance would be monitored with CBM. Teachers were instructed to select pairs who were performing similarly to each other and for whom teachers had no objections to implementing the same instructional program, including modifications, for both students throughout the year. Pretest information revealed that teachers did select comparably performing pairs of students; that is, no significant difference was observed in performance initially between the CBM target students and their partners. Progress monitoring occurred twice weekly, and teachers reviewed computerized CBM graphs and skills analyses for 42 CBM students every 1 to 2 weeks. For approximately every 6 to 8 data points, teachers raised goals when progress exceeded the slope of the goal line or when the most recent 4 data points all fell above the goal line. When student progress was less steep than the goal line or when the most recent 4 data points all fell below the goal line, teachers were prompted to make an instructional modification. Teachers had access to the CBM student's skills analysis to review relative mastery on the various problem types depicted on the CBM tasks. Teachers then made instructional modifications for both the CBM target student and his or her matched partner. A mathematics-computation test incorporating skills from the statewide curriculum in Grades 1 to 6 was administered on a pre- and posttest basis. At the end of 20 weeks, both CBM target students and their partners grew significantly in mathematics performance across the treatment period; however, CBM students significantly outperformed their matched partners. Thus, teachers were able to effect superior growth by making instructional program changes in concert with individual patterns of student performance. Clearly, teachers who monitored student progress systematically and responded to individual patterns of student performance by making programmatic changes exerted a powerful effect on student achievement.

Teacher Recommendations

A persistent problem reported by teachers who used CBM for progress monitoring was the formulation of instructional changes. Typical practice seemed to indicate that teachers implemented few instructional changes on their own. The addition of skills-analysis information helped teachers examine student performance and highlighted skills for remediation; however, most CBM studies incorporated some assistance by researchers in the field when teachers examined CBM data and made instructional decisions. This form of "expert" assistance was not formalized or studied systematically until the late 1980s and early 1990s. Wesson (1991) contrasted two types of expert assistance (individual vs. group) with two types of progress monitoring (conventional vs. CBM) in a 2×2 fully crossed design. Fifty-five resource and self-contained special educators selected 1 student from their reading caseloads for participation in this study. Teachers in the CBM groups received instruction in measurement procedures and decision making; teachers in the non-CBM groups received training in instructional procedures, materials, arrangements, and motivational strategies, but they were free to use their own methods for developing goals and progress-monitoring systems. For individual consultation, university staff who had been experienced teachers served as expert consultants. Monthly meetings were held with teachers to discuss IEP goals and student progress. Group consultation also took place on a monthly basis across this 5-month project, but teachers met in groups of 3 to share information about their instruction and progress monitoring. Oral-reading fluency measures collected pre- and posttest indicated that CBM groups of students grew significantly more than students whose teachers monitored progress in conventional ways. For the consultation comparison, the author reported that group consultation appeared to have a significant effect over individual consultation; however, no data were presented to corroborate this claim. In fact, the author contrasted directly the two types of consultation and reported no statistically significant difference. In view of some inconsistencies in the data analysis, the best conclusion appears to be that CBM progress monitoring positively affected student achievement in reading; however, no firm conclusion could be made about which form of consultation was superior.

Two studies, one in reading (L.S. Fuchs et al., 1992) and one in mathematics (L.S. Fuchs, Fuchs, Hamlett, & Stecker, 1991), contrasted directly (a) the use of a computerized expert system for aiding teachers with CBM instructional decision making with (b) CBM progress monitoring without any form of consultation. Additionally, student performance in both studies was compared to a third group in which teachers used their own progress-monitoring techniques. For CBM in reading (L.S. Fuchs et al., 1992), students completed a maze procedure at the computer in which a grade-level story was presented for $2\frac{1}{2}$ min. Students selected the correct word from three choices provided for every blank. In mathematics (L.S. Fuchs et al., 1991), students completed grade-level tests with paper and pencil while the computer timed the test administration and gave an audible signal when the appropriate time elapsed. Students entered answers at the computer. In both cases, the software saved and analyzed student responses. Teachers examined student CBM information and responded to a set of questions about their instructional programs when prompted by the expert systems. When student progress was inadequate to meet long-term goals, the expert systems provided instructional recommendations for the teacher to follow based on student-performance information and teachers' responses. Teachers who did not have access to the expert systems modified student programs when prompted by the CBM data-management software, but they formulated their own instructional modifications. In mathematics, however, all CBM teachers regardless of consultation condition had access to the skills-analysis information.

In reading (L.S. Fuchs et al., 1992), results indicated that both CBM groups modified student programs more frequently than did contrast teachers who did not use CBM. The Comprehensive Reading Assessment Battery (L.S. Fuchs, Fuchs, & Hamlett, 1989c) was given on a pre- and posttest basis. Students in both CBM groups significantly outperformed their non-CBM counterparts on oral-reading fluency and number of maze blanks completed accurately; however, the written retell measure distinguished student performance in the expert-system group. These students wrote significantly more than did students in both the CBM group without consultation and the non-CBM group. Thus, expert-system consultation appeared to benefit teachers by providing advice about instructional strategies, but did not appear to be a necessary condition for effecting student achievement.

In the mathematics study (L.S. Fuchs et al., 1991), a computation test incorporating skills from the statewide curriculum in Grades 1 to 6 was administered on a pre- and posttest basis. At the end of 20 weeks, results revealed significantly greater achievement on both digits and problems correct for the CBM expert-system group when compared to both the CBM skills-analysis group receiving no consultation and the no-CBM contrast group. Interestingly, these two groups did not differ from each other. This finding may appear initially to run counter to the earlier L.S. Fuchs et al. study in 1990 in which higher achievement was observed among students whose teachers had access to skills analyses; however, these teachers also had received ongoing consultation from project staff. Consequently, the L.S. Fuchs et al. study in 1991 was the first investigation to control systematically for the effects of consultation. Both CBM groups complied with decision rules and implemented the same number of instructional changes in mathematics programs, but differences in the nature of instructional changes were revealed on instructional planning documents. Teachers receiving consultation described more changes in instructional processes; that is, *how* they instructed students rather than just specifying the reteaching of skills identified as not yet mastered, as had been documented by the CBM teachers not receiving consultation. Consequently, instructional changes alone did not appear to produce substantial achievement gains. Rather, the nature and quality of interventions may be vital to student growth, and teachers may need some form of assistance in formulating sound instructional programs. Although teachers in the expert-system study in reading (L.S. Fuchs et al., 1992) were able to effect significant growth without consultation, the expert system constituted the more powerful CBM treatment across the greatest number of measures. Given that previous studies documenting the efficacy of CBM for progress monitoring and instructional planning also had incorporated some form of consultation (even if only informal instructional advice), instructional consultation appears to constitute an important component of CBM procedures. Table 1 provides a summary of the major experimental contrasts and results for the studies that examined CBM effects on the achievement of students with disabilities.

Summary of CBM Features Affecting Achievement for Students With Disabilities

Across the studies we reviewed, results indicate that five features may be critical for efficacious use of CBM with elementary- or middle-school students with mild to moderate disabilities. First, although progress monitoring alone does not seem to affect achievement, significant student gains are realized when teachers respond to the CBM database by tailoring the instructional program to student needs. Second, adherence to a data-decision framework that includes both goal raising when progress is higher than expected as well as implementation of instructional changes when progress is less than expected appears important for stimulating student growth. Third, computer applications for data collection, storage, management, and analysis may enable teachers to be more efficient in using CBM and contribute to overall satisfaction with procedures. Fourth, skills analysis, when available and when used in conjunction with consultation, also appears to provide information that may help teachers focus on aspects of student performance that are relatively strong or weak. Finally, some form of instructional consultation or ongoing recommendation system may be needed by teachers to devise meaningful programmatic changes.

CBM Used for Enhancing Student Achievement in General Education

Given evidence of efficacy of CBM for enhancing academic growth among students with mild to moderate disabilities and because inclusive environments had become increasingly popular settings for students with disabilities, CBM research shifted in the 1990s towards general education classrooms. Although computer applications increased the efficiency with which teachers could monitor progress across multiple students, several problems emerged with CBM implementation. CBM always had focused on the progress of *individual* students. General classroom teachers, then, were faced with the tasks of figuring out feasible ways to monitor the progress of all students in their classes, to evaluate individual patterns of progress, and potentially to devise different instructional modifications for different students at varying times. Stecker and Fuchs (2000) demonstrated that the same instructional programs delivered to more than one student effected greater growth among the particular students whose progress-monitoring data were used to devise those programs. Although the instructional programs enabled initially comparably performing students to grow significantly, students whose teachers used CBM data for instructional planning outperformed their matched partners who received the same instructional programs. The next logical step for CBM research centered on how technology could be used to summarize and analyze classwide CBM data and to provide instructional recommendations across students, both with and without disabilities, while still being responsive to individual performance. Next, we review several selected studies that illustrate these applications of CBM in general education.

Classwide Analysis and Instructional Recommendations

Research begun in 1990 culminated in classwide CBM analyses that provided several types of descriptive information about classwide performance. Although teachers could choose to examine individual graphs and skills analyses (see Figure 1) and students could view their own feedback, classwide applications of CBM also provided a class summary; that is, a profile of progress across all students in the class taking CBM tasks on a particular level. In Figure 2, the graph at the top illustrates rate of student progress across time on digits correct at the 25th, 50th, and 75th percentiles. Included in the report is a list of students who fell below the 25th percentile, and skills are identified on which students made improvement or stayed the same over the previous month's time. Additionally, a class-skills profile is provided much like the mathematics-skills analysis for individual students. The class-skills profile, though, depicts level of mastery on every problem type contained on the measures for the previous half-month interval for every student. A frequency count also is provided for the numbers of students who fell within each mastery category by problem type.

L.S. Fuchs, Fuchs, Hamlett, Phillips, and Bentz (1994) examined general educators' use of this class analysis with CBM in mathematics in Grades 2 to 5. Forty teachers were assigned to a CBM condition or a no-CBM condition. Teachers using CBM were divided further into a group receiving classwide feedback along with instruction recommendations or a group receiving classwide feedback but no instructional recommendations. All students in the class engaged in CBM tasks weekly. At least one student with an identified learning disability was included in each classroom. Twice each month, teachers received a computer-generated copy of all student graphs as well as the profile summarizing class performance. If the teacher received instructional recommendations on his or her report, information included skills to teach during whole-class instruction, the composition of small groups by skills on which students experienced persistent difficulty, and suggestions for tutors and tutees by skill for classwide peer-tutoring activities (see Figure 3). Although the other CBM group did not receive instructional recommendations, these teachers were not prohibited from conducting classwide peer tutoring; however, only CBM teachers receiving instructional recommendations were given peer-tutoring materials that included scripts for teacher's instruction and the student pairs by skill. Achievement effects were examined after 25 weeks for students who were low or average achieving or had learning disabilities.

Results indicated that teachers were able to implement CBM with relatively large numbers of students with fidelity and that their overall satisfaction with CBM procedures was high (L.S.

Table 1
Summary of CBM Research on Reading and Mathematics Achievement for Students With Disabilities

CBM Study	Major Contrasts	Treatment Length	Monitoring Measure(s)	Dependent Measure(s)	Achievement Results
Data-Based Decision Rules					
Tindal, Fuchs, Christenson, Deno, & Mirkin (1981)	(daily vs. weekly meas.) vs. (long- vs. short-term goal) vs. pre/posttest	12 weeks	word recognition fluency	oral reading fluency (ORF) on word lists	frequency of measurement = goal condition = pre/posttest contrast
Skiba, Wesson, & Deno (1982)	formative evaluation vs. contrast	~7 months	daily 1-min ORF from basal	ORF-3rd-grade passages (SDRT[a] subtests at posttest)	formative evaluation = contrast
King, Deno, Mirkin, & Wesson (1983)	formative evaluation vs. contrast	~7 months	daily 1-min. ORF from basal	ORF-3rd-grade passages (SDRT subtests at posttest)	formative evaluation = contrast
L.S. Fuchs, Deno, & Mirkin (1984)	data-based program modification vs. contrast	18 weeks	twice weekly 1-min basal ORF	ORF-3rd-grade passages (SDRT subtests at posttest)	formative evaluation > contrast for both measures
Jones & Krouse (1988)	data-based problem solving vs. contrast	8 weeks	twice weekly ORF, vocabulary, reading comp. unclear in math	ORF-2nd–3rd grade passages (adapted CAT[b] on comp. items at posttest)	formative evaluation > contrast in reading
				four tests of basic operations to yield 52 problems	formative evaluation = contrast in mathematics
L.S. Fuchs, Fuchs, & Hamlett (1989b)	CBM + evaluation vs. CBM without evaluation vs. contrast (retrospective study)	15 weeks	twice weekly recall or cloze administered by hand or computer	SAT[c] reading comp. subtest at posttest covaried with pretest written recall	CBM + eval > contrast; CBM + eval = CBM; CBM = contrast
L.S. Fuchs, Fuchs, & Hamlett (1989a)	CBM dynamic goals vs. CBM static goals vs. contrast	15 weeks	twice weekly 25 grade-level computational problems	Math Computation Test (36 problems, or 78 digits)	dynamic goals > contrast; dynamic goals = static goals; static goals = contrast

Skills Analysis					
L.S. Fuchs, Fuchs, Hamlett, & Stecker (1990)	CBM graphed data + skills analysis vs. CBM graphed data vs. contrast	15 weeks	twice weekly 25 grade-level computational problems	Mathematics Operations Test-Revised (50 problems, or 142 digits)	skills analysis > graphed data = contrast
Stecker & Fuchs (2000)	same instructional modifications for (a) CBM students and (b) their matched partners	20 weeks	twice weekly 25 grade-level computational problems	Mathematics Operations Test-Revised (50 problems, or 142 digits)	CBM students > matched partners
Teacher Recommendations					
Wesson (1991)	(CBM vs. no CBM) × (individual consultation vs. group consultation)	5 months	1-min ORF from basal	ORF-3rd-grade passages SDRT subtests	CBM > no CBM (on ORF)
L.S. Fuchs, Fuchs, Hamlett, & Ferguson (1992)	CBM + expert system (ES) vs. CBM vs. contrast	17 weeks	twice weekly computerized maze	Comprehensive Reading Achievement Battery (ORF, maze, retell)	CBM-ES = CBM > contrast (ORF, maze) CBM-ES > CBM = contrast (retell)
L.S. Fuchs, Fuchs, Hamlett, & Stecker (1991)	CBM skills analysis + ES vs. CBM skills analysis vs. contrast	20 weeks	twice weekly 25 grade-level computational problems	Mathematics Operations Test-Revised (50 problems, or 142 digits)	ES consultation > skills analysis = contrast

[a]SDRT = Stanford Diagnostic Reading Test; [b]CAT = California Achievement Test; [c]SAT = Stanford Achievement Test.

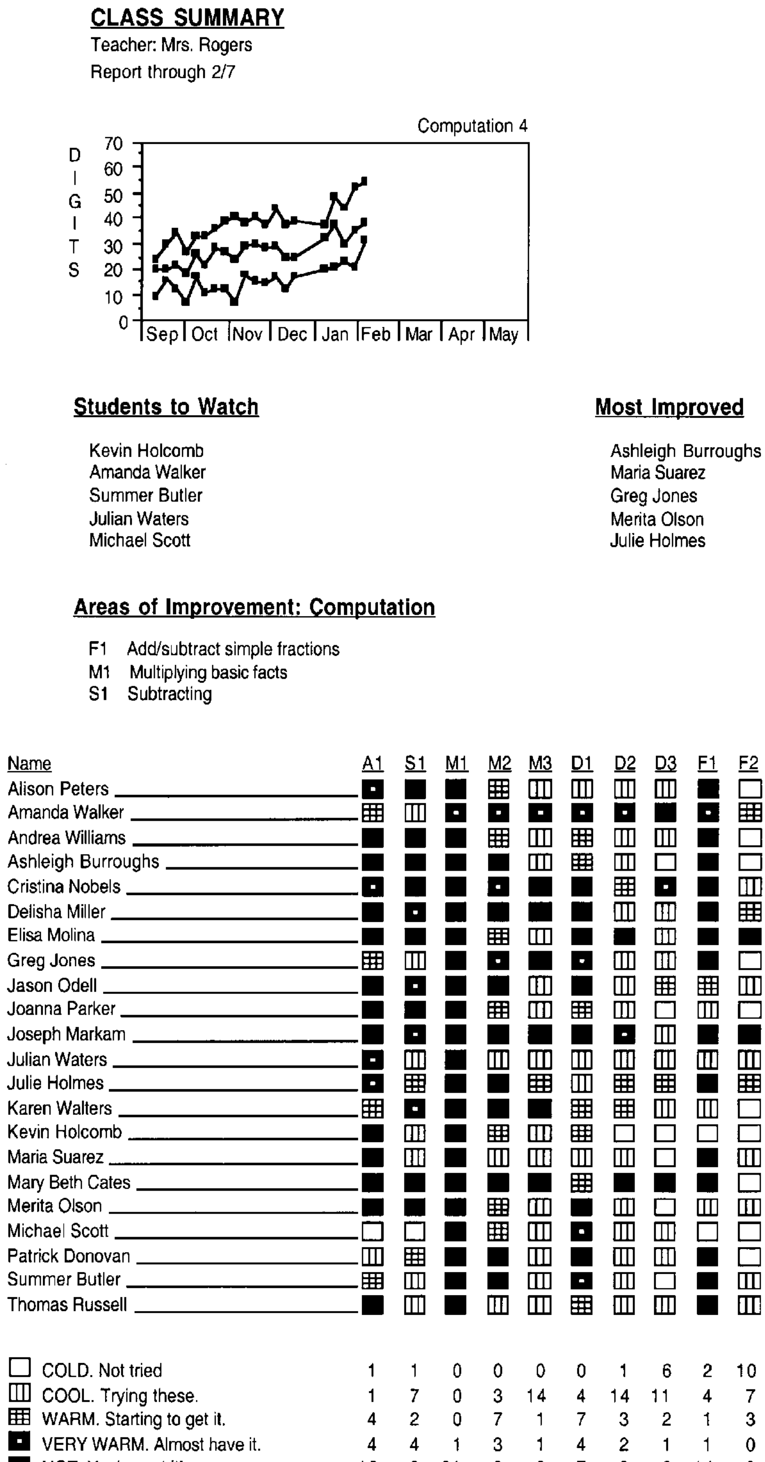

FIGURE 2. Classwide profile in mathematics computation.

PEER TUTORING ASSIGNMENTS

Teacher: Mrs. Rogers

Report through 2/7

S1 Subtracting	First Coach	Second Coach
	Ashleigh Burroughs	Patrick Donovan
	Andrea Williams	Julie Holmes
	Alison Peters	Thomas Russell
	Cristina Nobels	Greg Jones
	Jason Odell	Amanda Walker

F1 Add/subtract simple fractions	First Coach	Second Coach
	Elisa Molina	Michael Scott
	Mary Beth Cates	Julian Waters
	Joseph Markam	Merita Olson
	Maria Suarez	Karen Walters
	Delisha Miller	Kevin Holcomb
	Summer Butler	Joanna Parker

Whole Class Instruction: Computation

M3 Multiplying by 2 digits

64% of your students are either COLD or COOL on this skill.

Small Group Instruction: Computation

S1 Subtracting

Greg Jones	Thomas Russell
Maria Suarez	
Michael Scott	
Summer Butler	

FIGURE 3. Instructional recommendations for mathematics computation.

Fuchs, Fuchs, Hamlett, Phillips, & Bentz, 1994). Concerning achievement, however, students whose teachers had received both the classwide skills analysis and instructional recommendations performed better than the CBM group without instructional recommendations and the no-CBM contrast group on a 50-problem measure that systematically sampled problems across Grades 1 to 6 from the computational portion of the statewide curriculum. Additionally, average-achieving and low-achieving students grew significantly more than did students with learning disabilities.

Examination of instructional planning documents revealed that teachers receiving instructional recommendations also reported addressing more computational skills, delivering more instruction both one to one and with peers, and using systematic motivational systems more frequently than did teachers in the other two groups. Thus, teachers receiving instructional recommendations based on CBM data appeared to be able to use these recommendations to address classroom heterogeneity more effectively than teachers who did not receive recommendations with their CBM data or who did not have CBM information at all.

Although this study (L.S. Fuchs, Fuchs, Hamlett, Phillips, & Bentz, 1994) failed to separate effects of different aspects of the instructional-recommendations report, it appeared that classroom teachers needed suggestions for integrating CBM assessment data with their instructional planning. This finding corroborates results of previous studies utilizing feedback and recommendations for individual students with disabilities (e.g., L.S. Fuchs et al., 1992; L. Fuchs et al., 1991). Across CBM studies, types of teachers, and types of students, teachers appeared to require assistance in using CBM information to formulate sound instructional modifications to meet student needs. Moreover, this combination of CBM information and instructional recommendations seems to effect achievement across types of learners. In the general education classroom setting, however, students with learning disabilities did not fare as well as their nondisabled peers. Additional forms of instructional modifications may be necessary to produce greater achievement effects for learners with disabilities. Consequently, systematic examination of peer-mediated instruction became one way to explore instructional adaptation that could capitalize on the academic diversity apparent in general education classrooms.

Peer-Assisted Learning Strategies

Although classwide peer-tutoring procedures have documented achievement effects in reading, spelling, and mathematics for students of low socioeconomic status, work in peer tutoring by Greenwood and colleagues at the University of Kansas and by Fantuzzo and associates at the University of Pennsylvania was expanded in the mid-1990s to encompass methods that address all types of learners in the general education classroom (see L.S. Fuchs, Fuchs, Phillips, Hamlett, & Karns, 1995, for brief review of substantive features among different types of classwide peer tutoring). Using CBM data for examining classroom academic heterogeneity and pairing students who had mastered particular skills with those who had not, L.S. Fuchs et al. (1995) also sought to evaluate mathematics-achievement effects on the transfer of a computational peer-tutoring treatment to a mathematics concepts and applications domain. Forty general classroom teachers in Grades 2 to 4 participated in the study. At least one student with an identified learning disability was included for mainstream instruction. One half of the teachers implemented peer-tutoring procedures, known as peer-assisted learning strategies (PALS), with their students. The other group of teachers served as a contrast that used their standard procedures for progress monitoring and instruction. PALS teachers conducted peer tutoring twice weekly for 30 min each session, typically replacing independent work. Teachers changed the composition of the pairings every 2 weeks based on ongoing CBM information. Computerized feedback provided teachers with graphs and skills analyses for each student. Teachers taught students to interpret their own feedback by answering a series of questions about the scores on their graphs and about the boxes indicating mastery status. Additionally, teachers received a class report that summarized the performance across the class similar to the information provided to teachers in the L.S. Fuchs, Fuchs, Hamlett, Phillips, & Bentz (1994) study. Based on CBM data, suggestions for PALS included a list of students who could (a) provide or (b) benefit from assistance on particular skills. Teachers used this information to structure their pairings. The student in each pair who had mastered the skill served as the coach. Every student was given the opportunity to serve as coach at least once within every 6-week interval. Coaches modeled the skill to be addressed through a fading verbal rehearsal routine, for which prepared scripts of questions were used. Questions differed by problem type, but guided a student toward the problem's solution. Coaches provided feedback for every step of the procedure, including explanations and models for strategic behavior when students were incorrect. The student learning the skill practiced problems under close supervision of the coach and was allowed to attempt a problem independently only when the preceding problem had not required any corrections or explanations.

After 23 weeks of the PALS treatment (L.S. Fuchs et al., 1995), 50-problem measures that sampled the statewide curriculum for Grades 1 to 6 were administered in both computation and mathematical concepts and applications. PALS students grew more than did students in the contrast group from pre- to posttest. Growth on the 50-problem computational test (i.e., the acquisition measure that mirrored types of skills addressed in PALS) was greater than growth on the 50-problem concepts and applications measure (i.e., the transfer measure) for low-achieving students and students with learning disabilities; however, growth was comparable across the two measures for average-achieving students. Because teachers reported comparable amounts of time for mathematics instruction, overall achievement effects for the PALS students could not be attributed to extra instruction. PALS appeared to replace instructional components rather than supplement instruction. PALS effected greater growth among students with varying achievement histories and thus could be used to accommodate academic diversity within general education classrooms; however, the transfer effect to the broader mathematics curriculum that included concepts and applications was not as great for students with learning difficulties as it was for average-achieving students. Consequently, the next step with peer-tutoring procedures involved the examination of more comprehensive methods that encompassed greater portions of the curriculum than basic facts or procedural content.

L.S. Fuchs et al. (1997) extended use of PALS with CBM to include instruction in conceptual explanations. Forty general classroom teachers in Grades 2 to 4 were assigned randomly to one of two PALS conditions or to a contrast group that conducted conventional methods of progress monitoring and instruction. Both PALS conditions utilized previous peer-tutoring procedures of mediated verbal rehearsal on skills identified through CBM, but instruction in elaboration was added. Students in the PALS plus elaborated feedback condition were taught in a 1-day session how to provide and seek elaborated help (e.g., paying close attention to partner's work, explaining how the answer was derived and asking partner to repeat information to show understanding, or specifically asking for help). In addition to instruction on elaborated feedback, the second PALS condition included 3 days of instruction on conceptual explanations. Coaches were taught to illustrate and explain problem types by performing such tasks as building number sentences that incorporate real-life scenarios, making marks or pictures to stand for numbers, using manipulatives as concrete objects that stand for numbers, discussing why a problem must be worked in a certain way or why a particular answer does not make sense, and asking step-by-step questions that focus on what, where, when, how, and why. In addition, teachers held a 5-min debriefing session after peer tutoring to discuss students' use of conceptual explanations.

Following 18 weeks of treatment implementation (L.S. Fuchs et al., 1997), 50-problem measures that sampled the statewide curriculum for Grades 1 to 6 were administered for both computational skills and mathematical concepts and applications. Results on both measures indicated that the students giving and receiving conceptual explanations outperformed students in the other two groups; additionally, students in the PALS plus elaborated feedback condition grew significantly more than did contrast students from pre- to posttest; however, students who worked with conceptual explanations provided more procedural questions and conceptual explanations than did students in the elaborated- feedback-only condition. These conceptual explanations were associated with better growth on measures in both areas of mathematics performance: computation and concepts/applications. Differential effects by student type approached significance. Tentative follow-up tests revealed that high performers and low performers appeared to benefit the most from the conceptual-explanations condition. The research team speculated that decision rules used with CBM recommendations may have contributed to this effect. For partner pairings, recommendations were provided for the highest performing student to be paired with the lowest performing student, the next highest performing student with the next lowest performing student, and so on. This method may have produced opportunities for high performers to benefit by having to develop rich explanations for their low-achieving partners. Average-achieving students, on the other hand, tended to be paired with each other, decreasing the number of opportunities to engage in deeper, more integrative thought that might facilitate one's own understanding of new skills or retention of previously learned skills. Additionally, the effect size associated with improved achievement was much larger for low-achieving students than for the students with learning disabilities. Consequently, developing peer-mediated interventions that are strong enough to effect significant change among students with learning disabilities continues to be problematic. The enduring nature of learning problems experienced by this population probably contributes to this finding. Nevertheless, these treatments showed that interactional styles of young students can be enhanced through explicit instruction in principles of elaborated assistance and can endure over a relatively long period of time (i.e., 10 weeks).

Conclusions

Summary of Findings

Across the investigations that examined effects of CBM on the achievement of students with disabilities, we draw several conclusions. First, teachers effected significant growth with CBM progress monitoring if they simultaneously implemented modifications in their instructional programs when warranted by student data; however, frequent progress monitoring alone (i.e., without instructional modifications) did not appear to boost student achievement. Second, the use of data-based decision rules for interpreting graphed CBM data appeared to enable teachers to be responsive to student needs (i.e., to make decisions about when programs needed modifications for particular students). Third, computer applications facilitated the use of decision rules and included a goal-raising feature that also stimulated student growth. Overall, computer applications contributed to teacher satisfaction with CBM procedures. Moreover, computer programs that incorporated student data collection as well as data management reduced teacher time devoted to CBM procedures and enhanced feasibility and utility of the system.

Computerized CBM systems can yield additional benefits. For example, computer applications that provide extensive feedback to teachers, such as skills analysis, can summarize copious amounts of student-performance information very quickly. Across studies, skills analyses appeared helpful to teachers when they planned modifications; however, without consultation or instructional recommendations, teachers experienced difficulty in using CBM to plan instructional programs. Therefore, teachers appeared to need ongoing support for utilizing CBM information to tailor programs to meet individual needs.

In general education, teachers who used classwide CBM data and recommendations for instructional planning effected greater growth among their students who exhibited a range of learning histories than did contrast teachers who used their own methods for progress monitoring and instruction. Part of these instructional recommendations, however, included implementation of PALS. Therefore, incorporation of PALS with CBM was studied systematically. Because PALS was associated with improved student achievement, PALS became another critical variable in the use of CBM, especially in general education classrooms. PALS appeared to enable teachers to accommodate academic diversity by providing a structure for instructing and practicing the particular skills individual students needed. CBM data and classwide feedback with recommendations facilitated teachers' decision making regarding implementation of PALS. But one caveat remains: Although significant growth was generally robust across students of varying academic histories (i.e., high-, average-, and low-achieving students as well as students with disabilities), achievement gains were not uniformly large by student type. Therefore, the next generation of CBM applications must continue to examine instructional treatments systematically to develop the best combination of procedures for effecting growth across various types of learners.

Future Directions

In addition to the development of more comprehensive treatments that accommodate greater diversity among students as documented by CBM data, expansion of CBM feedback may enable teachers and the consultants working with them to plan instruction that is more individually responsive. For example, current work investigating diagnostic feedback in reading (L.S. Fuchs, Fuchs, Hosp, & Hamlett, 2003) may provide richer information about students' reading skills based on oral-reading fluency than what has been supplied previously. In addition, researchers continue to enlarge the domain for CBM content to include secondary material (e.g., Busch & Espin, 2003; Espin & Tindal, 1998), early writing (e.g., Lembke, Deno, & Hall, 2003), early reading (L.S. Fuchs, Fuchs, & Compton, 2004), and phonics skills (e.g., Stecker, 2000). With documented technical adequacy of CBM for decision making and increased accountability based on student outcomes, CBM data will likely be used progressively more to predict performance on high-stakes tests. As technological developments move CBM toward Web-based approaches for progress monitoring and performance feedback across classes, schools, and districts, administrators must recognize that teachers will need systematic support in interpreting and using CBM data for instructional planning. Technology may resolve some issues surrounding large-scale implementation and data-based evaluation, but the real issue related to CBM appears to be teachers' effective use of the data. Modifying programs for different students at different times or determining what changes constitute potentially sound program revisions for different types of learners remain challenges for teachers, support services, and teacher-preparation programs. Systematic investigations of CBM and its applications during the next decade are likely to yield academic benefits for students with varying learning histories by enabling their teachers to use instructionally related assessment effectively when planning and implementing instruction.

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