Using a Curriculum-Based Instructional Management System to Enhance Math Achievement in Urban Schools

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More than two-thirds of students living in U.S. low-income urban areas have not demonstrated basic levels of math achievement. Teachers are confronted with a difficult task of meeting the needs of an increasingly academically diverse population of urban students. There is a well-confirmed knowledge base on effective instruction, but teachers need massive amounts of information for effective, sustainable improvement and data-driven decision making. The bottleneck to improving teaching and
learning is a lack of systematic, usable information on individual student performance and progress at the classroom level.

We examined the effect of adding a computerized curriculum-based instructional management system as an enhancement to ongoing math instruction. Two math tests were used to contrast performance gains for students in the treatment group in comparison to two control groups: a same-school math instruction-only group, and a randomly selected district-wide math instruction-only group. Teachers in our experimental group implemented the treatment with varying degrees of fidelity, so we examined the impact of the level of implementation on student performance. We also examined the extent to which the treatment worked differently for high, middle, and low achieving students.

There were positive outcomes for students in classrooms in which teachers used the instructional management system (Accelerated Math [AM]). In fact, students enrolled in classrooms where teachers implemented the AM intervention to a greater degree benefitted the most. Gains in math performance were consistent for high, middle, and low performing students. Use of a computerized instructional management system enabled teachers to differentiate instruction, make instructional adaptations for students of all ability levels, and provide students with relevant practice and immediate informed feedback. It also resulted in significant gains in math achievement.

The level of academic achievement for students in the United States is a national concern. More recently, in the Third International Mathematics and Science Study (TIMSS) in 1995, U. S. eighth graders scored below the 41-nation international average in math. In particular, eighth grade students from 20 countries outperform U.S. students, a finding that has reinforced concerns about math achievement. At a national level, according to newly released National Assessment on Educational Progress (NAEP) data, only 26%, 27%, and 17% of 4th, 8th, and 12th graders, respectively, were performing at or above the proficient level in math. Land and Legters (2002) documented the low-level performance of the nation’s 4th-, 8th-, and 12th-grade students on the math portion of NAEP and the over-representation among those who performed most poorly of students who evidence the five risk factors cited by Natriello, McDill, and Pallas (1990): poverty, race–ethnicity, limited English proficiency, poorly educated mothers, and single parent families.

Since 1983, major academic and school reform strategies have been enacted to address low-level math achievement. School personnel have responded by

1. Writing or rewriting standards.
2. “Ratcheting up” current standards.
3. Building accountability systems that include all students.
4. Developing new programmatic interventions.
5. Extending the school year.
6. Implementing specific remedial programs targeted at students from groups over-represented among low performers.
Land and Legters (2002) documented further the relation between urbanicity and greater risk of low-level academic outcomes. Math performance in urban districts continues to lag behind national performance levels and there are sustained achievement gaps among racial–ethnic groups. Thus, within urban districts—districts that primarily educate large populations of immigrants and students of color—the need to provide assistance in math instruction has never been greater.

EVIDENCED-BASED PRINCIPLES OF EFFECTIVE INSTRUCTION

As urban districts continue to focus on improving overall achievement of their students, particularly in math, there is a need to find ways to implement evidence-based principles of effective instruction. There are well-established links between effective instructional delivery and positive achievement outcomes repeatedly evidenced in the educational and psychological literature. As educators investigate instructional correlates of positive educational outcomes, the same core factors emerge. These critical factors, foundational in nature, include reinforcement, feedback, cooperative learning, personalized instruction, adaptive instruction, and monitoring of student performance.

Christenson, Ysseldyke, and Thurlow (1989) synthesized the literature on effective instruction and identified 12 critical instructional factors. These factors include the following: effective and efficient classroom management, a sense of “positiveness” in the classroom, an appropriate instructional match, clearly stated goals and expectations, clearly presented lessons, individual instructional support, sufficient allocation of time for instructional activities, high opportunity for students to respond, active monitoring of student progress and understanding by the teacher, and frequent and appropriate evaluation of student progress by the teacher.

Gettinger and Stoiber (1999) provided similar evidence about critical instructional factors that enhance student learning. These factors included encouraging high student engagement in learning, having a strong academic focus and clarity of content coverage, facilitating moderate to high success rates, and performance monitoring and informative feedback. Additionally, they discussed the positive effects of goal setting and its relationship to academic outcomes. In Table 1 we have listed a set of critical instructional factors merged from the multiple literature syntheses, and summarized by Ysseldyke and Christenson (2002).

Collectively, these empirically demonstrated principles of learning, if effectively applied, increase the probability of producing significant improvements in student outcomes. Unfortunately, translating research into practice is accompanied by many challenges. Although researchers have identified many instruc-
Incorporating factors that are related to positive educational outcomes for students, in a typical classroom of 25 to 35 students is far from easy (Stipek, 1996). Somehow teachers must identify appropriate instructional levels for the academically diverse students in their classes, adapt instruction to meet individual student needs, and pace instruction for different students. They must provide relevant practice and corrective feedback, monitor individual student progress, and use data on student performance to plan and deliver subsequent instruction. The task is pretty overwhelming without help, and is magnified as diversity increases.

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<tr>
<th>Evidence-Based Instructional Practices (Practices Shown Significantly Related to Improved Educational Outcomes)</th>
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<td>Instructional match</td>
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<td>Academic engaged time</td>
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<td>Adaptive instruction</td>
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<td>Student understanding</td>
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TWO ESPECIALLY CRITICAL FACTORS:
INSTRUCTIONAL MATCH AND
ACADEMIC LEARNING TIME

Research is definitive about the importance of matching academic assignments to individual students’ abilities (Slavin, Karweit, & Madden, 1989). One way to evaluate whether a student’s instructional level is appropriate is to examine the rate of success a student has on a particular instructional task. For example, many researchers have identified the link between student skill level, assigned tasks, and student achievement gains (Din, 1998; Gersten & Carnine, 1981; Gickling & Armstrong, 1978). With slight variations it is commonly recommended that the student success rate on independent assignments reach 80% for instructional tasks and 90% for review (Din, 1998; Gickling & Armstrong, 1978).

Extensive research also links students’ use of time in the classroom to student achievement outcomes (Greenwood, 1991). Greenwood and his colleagues (Greenwood, Carta, & Kamps, 1994) consistently have demonstrated that students’ academic responses and the extent to which they will profit from instruction are dependent on how they spend their time in school, and that this, in turn, is dependent on specific features of the classroom environment. Instructional features that can increase the amount of time a student spends engaged in an academic task that is matched to his or her skill level are strong predictors of student achievement (Fisher et al., 1980). Student engagement, sometimes referred to as Academic Learning Time (ALT), can be defined as “the amount of time a student spends engaged in an academic task which he can perform with high success” (p. 8). Thus, student engagement and rate of success become critically interrelated in understanding the science of student learning.

ALT is comprised of three basic components: (a) the total amount of time allocated for instruction, (b) the student’s academic engagement rate, and (c) the success rate. Unfortunately, the level of student engagement within classrooms often is an untapped resource. Previous studies have documented all too well the limited amounts of time students are actively engaged in classrooms across the United States, often less than an hour per day (Graden, Thurlow, & Ysseldyke, 1982; Stanley & Greenwood, 1983). Thus, if educational interventions can be designed to alter classroom features—to increase students’ academic engagement rates—they would potentially hold the most promise to accelerate academic learning.

CURRICULUM-BASED MONITORING SYSTEMS

Curriculum-based measures are a well established, empirically-based technology that can be used to monitor student performance across time and that have been shown to be reliable and valid for enhancing the level of information educators need to modify individual instruction for students (Deno, 1985; Fuchs & Fuchs, 1988). A
curriculum-based measurement system (CBM) is a “standardized methodology that specifies procedures for selecting test stimuli from student’s curriculum, administering and scoring tests, summarizing the assessment information, and using the information to formulate instructional decisions in the basic skills areas” (Fuchs & Fuchs, 1988, p. 3). More specifically, the performance of students across standard tasks can then be used by teachers to monitor progress and adapt instructional programs as needed for each student individually (Deno, 1985, 1986). The overall goal of this type of instructional system is to frequently assess ongoing work, monitor individual progress, provide informative feedback to students, adapt instruction as needed, and ultimately improve student overall performance.

**CURRICULUM-BASED MANAGEMENT SYSTEMS**

Recently one computer-based program, Accelerated Math™ (AM), developed by Renaissance Learning, Inc. (1998a), has shown promise as a curriculum-based management system. This system provides a possible solution for managing the complex set of tasks faced by educators today that are nearly impossible to do without the assistance of technology. The intervention is based on six “Renaissance principles” (Renaissance Learning, 2002):

1. Increased time to practice essential skills.
2. A match between student skill level and the level of instruction.
3. Direct and immediate feedback to teachers and learners.
4. Personalized goal setting.
5. The use of technology to process, store, and report information.
6. Universal success.

Students are pretested and, based on their performance, assigned to appropriate instructional levels. The computer generates on-level practice exercises, students respond to these exercises, score them by scanning them, and then the computer provides immediate feedback to the student and the teacher. Teachers are provided with summary information detailing the quantity and quality of each individual student’s performance in math. They use this information to enhance instruction, individualize instruction, adapt instruction, and group students for instruction. At face value, AM *should* work to enhance student math outcomes; it incorporates nearly all of the evidence-based components of effective instruction.

By using the AM software, teachers can manage multiple instructional tasks, such as matching practice items to students’ skill level, providing a continuous stream of practice items, monitoring individual and class progress, and providing immediate feedback on performance via numerous reporting features. Although much of this information is presently available at a classroom level, it is often unre-
alistic and unmanageable for teachers to organize without the assistance of computer technology. It is hypothesized that by using computer technology educators will be able to organize classroom level information—heretofore unmanageable—into useful individual student level programming and therefore enhance the performance of participating students.

Several independent researchers already have been able to demonstrate positive effects of AM on student math performance in urban districts. In a study by Spicuzza and Ysseldyke (1999), the effects of this curriculum-based management system on student math performance were examined during a 6-week summer school program in an urban district. Results indicated that students using AM showed an average gain of 5.75 Normal Curve Equivalents (NCE) units on the Northwest Achievement Levels Test (NALT), a district math achievement test. In a more expansive study by Spicuzza et al. (2001), the effects of AM on math achievement and classroom features known to be related to student achievement outcomes were found to be significant across high, middle, and low performing students. Finally, Teelucksingh, Ysseldyke, Spicuzza, and Ginsburg-Block (2001) studied the effects of consultation procedures used together with the AM curriculum-based management system for English Language Learning (ELL) students and found significant outcomes. Overall, the results of these studies collectively indicate that students who participated in AM classrooms demonstrated more growth on measures of mathematics than students who did not participate.

LIMITATIONS OF PREVIOUS RESEARCH

Although the results from previous studies demonstrate clear and significant results leading to improved performance for students in a large urban district, several research questions remain. For example most studies to date have been for limited periods of time. Thus, a likely extension of this research would suggest examining the impact of longer periods of time, and replicating previous outcomes across more classrooms in an urban setting that includes students with diverse instructional needs. In addition, given the propensity of teachers to implement interventions with varying degrees of fidelity, the classroom level of implementation and student outcomes need to be examined.

This study was designed to examine whether adding the use of a computer-based management system, like AM—one that incorporates core features of effective instruction—to an ongoing math curriculum would result in positive changes in math achievement. Specifically, the research questions were as follows: (a) Does the use of AM by educators lead to greater student math achievement compared to students not monitored using the assistance of technology that the AM program provides? (b) Do students at various skills levels (e.g., high, middle, and low achieving students) demonstrate greater improvement in math achievement when teachers use AM
along with the district math curriculum? and (c) To what degree does the integrity of implementation of AM impact student math achievement?

**METHOD**

**Participants**

Participants in this study were part of a multiple-grade project conducted at four elementary schools enrolled in a large urban school district in the Midwest from September 1999 through June 2000. Entire school demographics are provided in Table 2 by site.

A total of 397 students participated in the AM intervention across the four sites. Demographic information is listed for the AM participants in Table 2. Students were enrolled in the third, fourth, and fifth grades with approximately equal numbers of male and female participants. Approximately 75% of the participants were students of color receiving free or reduced-price lunch (67%). Additionally, 30% of the participants were receiving ELL services and approximately 13% were enrolled in special education programs. A total of 18 classrooms with 14 female and 4 male teachers had access to the AM program; teachers were trained after obtaining principal support for participating in the study.

The school district that the study was conducted in required that teachers volunteer to participate in this study and that we implement the intervention in classrooms of all teachers who volunteered to participate. There could be no random assignment of teachers to the experimental condition. It is also the case that those who volunteered implemented the intervention with varying fidelity. Thus, we made fidelity of implementation a dependent variable, and used two comparison groups as controls. First, performance was compared to within-school students who were not enrolled in AM classrooms. This comparison group (C1) consisted of 484 students (all students enrolled in Grades 3–5) from three of the schools in which AM was used (see Table 2). A second comparison group (C2) consisted of 429 students who were randomly selected from the district’s annual testing database. For achievement analyses, a sample of students was selected from each comparison group to represent three different achievement levels. We selected the top 20% of students, the middle 20%, and the bottom 20%. Demographics for each group of students are displayed in Table 2. Limitations of the naturally-occurring, nonrandom assignment of teachers to condition and students to classrooms are addressed in the Discussion section.

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1One participating site included all students in Grades 3 to 5. Therefore, no within-school comparison students were available.
Degree of Classroom Implementation

As is the case with many interventions implemented in complex and large urban environments, we had varied fidelity of treatment and intervention integrity. We used treatment integrity as an independent variable. Each participating classroom was classified according to a specified level of implementation or the degree to which staff were able to implement the intervention according to the specified standards. The level of implementation was determined by examining the number of mean objectives mastered and the mean number of problems attempted by each class, calculated at the end of the school year. Classrooms coded as “Partial Implementers” had a mean range of objectives mastered of 1.6 to 21 (for the entire class), whereas the range for full implementers was between 22.7 and 90. For the mean number of problems attempted, the range for classrooms classified as partial implementers was from 76 to 524, whereas the range for classrooms identified as full implementers was from 584 to 1349. Overall, of the 18 classrooms in the study, 10 were coded as full and 8 as partial implementers (see Table 3).

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2Renaissance Learning identifies specific pacing schedules for students to complete grade level libraries within an academic year. Model classroom standards range from 2 to 4 objectives per week.
Materials

Curriculum. The participating school district uses Everyday Math (EM) as the primary math curriculum in the elementary grades. Within the curriculum, there are goals and objectives that all students need to learn, as well as an elaborate set of standards articulating Grade Level Expectations identified by the district. As with most curricula, teachers must use curriculum materials as well as their own set of instructional strategies to convey this information to students.

Intervention. Each classroom teacher was provided with training and a copy of the AM software. Then, each student was placed into an instructional library that matched his or her individual achievement level as measured on the STAR Math Assessment. The AM program produces individualized practice assignments for students using an Algorithm Problem Generator. This allows each student to work on assignments at his or her own pace with a continuous supply of new problems and assignments. Students work on math practices printed by the program at their seat and then scan their completed answers into the computer. AM scores assignments and keeps records of student and class performance. It also provides information to students on their performance, and to teachers on individual and class-wide progress.

Teachers were trained on how to use the AM software during a training session held in October 1999. The training session was conducted by certified training staff from the Renaissance Learning Institute. In addition to this training session, a graduate research assistant was assigned to each school to meet with teachers periodically and answer questions related to the software and the implementation of AM in their classroom. We purposely kept the study as naturalistic as possible. Each teacher decided how he or she would integrate the software program into class instruction. The method of implementation of AM, classroom math instruction, and amount of practice varied by teacher. Each teacher decided how he or she would integrate the software program into class instruction.
Achievement Measures

**Northwest Achievement Levels Test.** Each year, all students in this urban district in Grades 2 to 7 are tested on the math portion of the NALT (Northwest Evaluation Association [NWEA], 1999). The district NALT test consists of a series of eight achievement levels at the elementary grades that measure student performance in a number of domains. Some of the domains included are number sense, measurement, relations, functions, randomness, and data investigation. Student performance is reported on a developmental Rasch-scale and percentile ranks based on the national user group (NWEA, 1999).

Level testing allows students to be given tests that are appropriate for their individual achievement levels based on prior testing information or a short locator test administered a few weeks prior to annual testing within the participating district. Another advantage of the NALT (NWEA, 1999) assessments is that national user norms are available to determine expected growth using the scale scores.

The NALT was normed on student test data gathered between the Fall of 1996 and the Fall of 1998 by the NWEA (1999). There were over 545,200 students included in the norming sample from 105 school districts in 18 states. Urban, suburban, and rural districts were included in the norming sample. Compared to the most recent U.S. census data available at the time of norming, the NWEA population had a slightly larger number of American Indian/Alaskan native, White, and Asian students, whereas there were fewer Black and Hispanic students than in the national population.

Reliability of the NALT was calculated during the 1995–1996 school year using 37 school districts in 10 states. The average sample size per grade was approximately 20,000. The reliability coefficient at Grades 3 through 7 ranged from .93 – .94 (NWEA, 1999). To determine a validity coefficient for the NALT, it was correlated with the Iowa Test of Basic Skills (ITBS) in 1999. In the area of math, the correlation between the two measures was .903 (NWEA, 1999). In a study by Heistad and Spicuzza (2000), predictive and concurrent validity coefficients were calculated between the state of Minnesota’s High Standard Exam, referred to as the Minnesota Comprehensive Assessments, and the participating district’s annual math exam. Grade 2 district math scores had a predictive validity of .80 and Grade 4 performance correlated even higher ($r = 0.86$). Concurrent validity coefficients were higher still between the district measure and the state’s high standards exam $r = .87$ and .89 for Grades 3 and 5, respectively. All students in the experimental and comparison group were tested on the NALT along with other students in the district under the standard procedures employed by the district each year.

**STAR math test.** Students were also assessed on the STAR Math test (Renaissance Learning, 1999b), a computer-adaptive test of math skills. This test was designed for use with students in Grades 3 through 12 and measures skills in nu-
meric concepts, computation, and math application. The test consists of 24 multiple-choice questions and students are allowed a maximum of 3 min to answer each question.

The STAR Math test is used for several purposes. This test provides information related to individual student performance in math and assists in appropriately placing students at their current level of achievement in the AM program library assignment, as previously noted. This test also provides information related to student growth in math performance using a pre- and posttest design. Another feature of this computer-adaptive test is that it allows for continual monitoring of progress throughout the academic year if multiple tests are administered to students.

The adaptive branching technology used with this system continuously adjusts each test to the abilities of the individual. Students who answer questions correctly are then presented with a more difficult item, whereas those who answer questions incorrectly are given an easier item. Essentially, the test is designed to focus on a student’s individual instructional level. The STAR Math test provides grade equivalents, percentile ranks, and normal curve equivalent scores.

The STAR Math test was normed in the spring of 1998 and standardized on 25,800 students who attended 256 schools in 42 states. The sample of students selected was stratified on the basis of geographic region, school location (urban, rural, and suburban), sex, and ethnicity. The sample is representative of the U.S. population.

Test–retest reliability was calculated with 1,541 students who took alternative forms of the test. The reliability coefficient at Grades 3 through 6 is in the high .70s, whereas at the higher grades they are in the .80s. The validity of the STAR Math test was determined by correlating STAR Math performance with the performance of various standardized math tests administered during the standardization of the test. Some of the comparison tests included the California Achievement Test, Comprehensive Test of Basic Skills, Iowa Tests of Basic Skills, and Metropolitan Achievement Tests. Validity scores were moderately high (Renaissance Learning, Inc., 1998b).

All students in the AM participant group and comparison group participated in pretesting on STAR Math in September 1999. All students completed a posttest on STAR Math at the end of the school year (May/June 2000). Students were tested in computer labs and supervised by their teacher or lab assistants.

Analyses

The performance of students participating in AM instruction was compared to the performance of students within the same schools (C1) whose teachers did not use AM, and then to within-district performance of randomly selected students from district test files (C2) who did not have access to AM. An analysis of covariance was conducted comparing AM participants to these two groups for each measure.
(STAR™ and NALT). Students were included in analyses if they had pre- and posttest scores on both the STAR and NALT measures.

RESULTS

Achievement: Within-School Comparisons

For the first series of analyses, students within the same school who were enrolled in classrooms with access to AM were compared to students who were enrolled in classrooms that did not have access to AM. Students were not randomly assigned to classrooms, but rather enrolled in classrooms where teachers had access to AM or did not have access to AM. Therefore, an analysis of covariance was performed with pretest scores as the covariate and posttest scores as the dependent variable.

The results of the analyses for both the NALT and STAR Math™ tests indicated a positive effect of the AM treatment. Overall, students enrolled in classrooms classified as demonstrating a high integrity of intervention implementation demonstrated more growth than students who were enrolled in classrooms that were classified as partial implementation or enrolled in classrooms that did not have access to the AM software, $F(2, 459) = 4.126, p < .02, d = .13$. There was no difference between partial participants and non-participants. The adjusted mean for full participants was 56.9. For partial participants it was 53.7 and for the nonparticipant group it was 53.7 (see Figure 1). On the STAR Math™ test, there was a significant effect for the treatment, $F(2, 459) = 11.05, p < .000, d = .21$. Students in the full-participation group had an adjusted mean of 53.2. Students in the partial participation group had a mean of 46.8, which was similar to the nonparticipation group, for which the mean was 45.8 (see Figure 1).

![Figure 1](image-url)
Within-School Comparison: High, Middle, and Low Performers

In addition to statistical analyses comparing mean differences, we employed a 20/20 analysis, a term coined by Reynolds and Heistad (1997). A 20/20 analysis is the examination of continuously enrolled students across time that isolates students performing at the top and bottom (fifth) margins of a distribution, as well as students at the median level. The primary rationale for focusing on students at these identified margins is that these are the students who most clearly require adaptation in instruction that accounts for their exceptional status, high-above or well-below grade level norms (Reynolds & Heistad, 1997). By having information about students at the margins, teachers and administrators are able to examine the trends for each proficiency level within a school and instantly determine if the instructional programming has become too “specialized,” so that only specific levels of students are benefitting. Thus, a 20/20 analysis maintains the focus and monitoring of student performance across the full continuum of student abilities and skill levels and avoids creating a reporting system that masks discrepancies in student performance by reporting only mean performances.

A 20/20 analysis is conducted by plotting the scores of students who perform at the top fifth, the median, and the bottom fifth of the sample. Issues related to regression to the mean are accounted for by plotting the NCE score that separates these points in the distribution at Time 1 (pretest) and then Time 2 (posttest), and therefore represent points within the distribution and not specific student scores. For a more detailed description of 20/20 analyses, see Reynolds and Heistad (1997), and Reynolds, Zetlin, and Wang (1993). The 20/20 analyses are displayed in Figures 2 and 3.

NCEs are a method for equalizing performance across a range of test scores, allowing direct comparison of student performance at any point on the test performance continuum as well as across time. NCEs range from 1 to 99, like percentile ranks, but are equalized into units of similar magnitude across the full range, unlike percentile ranks. If students perform at a consistent level of performance relative to their peers (45th percentile Time 1 and the 45th percentile Time 2) the students’ NCE growth would be zero (or a horizontal line on a graph). Students are considered to be gaining new skills (absolute knowledge), but not at an accelerated rate so as to increase their overall standing in comparison to same-grade peers (relative performance). Conversely, when an NCE gain is above zero, the outcome observed is an acceleration of a student’s rate of achievement and trend lines are displayed with an increased slope.

As noted in Figures 2 and 3, all ability groups demonstrate accelerated rates of performance compared to national norms. This finding suggests that not only are gains in absolute knowledge occurring, but relative performance also has improved across high, middle, and low performing students. Student performance...
FIGURE 2  Pre- and posttest performance on STAR math of students in top, middle, and bottom 20%.

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<td>Top 1/5</td>
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FIGURE 3  Pre- and posttest scores on NALT of students in top, middle, and bottom 20%.

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<td>Top 1/5</td>
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measured on the STAR Tests suggests almost identical accelerated slopes as noted by the parallel lines, and NCE gains ranged from 8.9 units to 11.1 units. Similar strong gains are captured by the district’s annual measure (NALT) with gains ranging from 3.4 to 10.8 NCE units. Regardless of the measure used, high, middle, and low performing students surpass national norms (80th, 50th, and 20th percentile) after beginning below national norms prior to participating in the AM intervention.

District-wide comparison. For the within-district analyses, comparisons were made between the AM participants and the random sample from the district’s testing database. NCE scores were used in an analysis of covariance with grade level and treatment as factors. Because the STAR Math test was not administered to the district comparison group (C2), only analyses on the district NALT scores were possible. In the comparison in which the groups were analyzed as a whole, once again the treatment showed a significant effect, $F(1, 429) = 8.79, p < .01, d = .14$. The adjusted mean for students who participated in AM was 50.07. For students in the district comparison group, the adjusted mean was 47.00. Grade level was also significant, $F(1, 429) = 26.56, p < .000, d = .24$. Fifth-grade students in these two groups demonstrated more growth on the NALT than the fourth-grade students.

Next, the performance of AM participants and the district comparison students were examined by skill level. Because grade level was found to be a significant factor in the whole-group analysis and chi-squared analyses indicated the groups had an unequal number of students in each grade ($\chi^2 = 7.56$), grade was added as one of the factors in the analysis by skill level. Again, there was a significant effect of the AM treatment, $F(1, 273) = 4.63, p < .05, d = .13$, with AM participants outperforming comparison students. Grade was also significant, in that fifth-grade students demonstrated more gains than fourth-grade students did, $F(1, 273) = 17.67, p < .000, d = .25$. Finally, skill level had an effect on how much growth students demonstrated on the NALT, $F(1, 273) = 6.94, p < .001, d = .22$.

DISCUSSION

The 2000 NAEP report clearly identifies the challenge faced by large urban districts. Although small gains were noted in the area of mathematics, these gains are not universally demonstrated among urban, suburban, and rural areas. Overall, test performance at a national level indicates that over two-thirds of students living in low-income, urban areas across the country have not been able to demonstrate basic levels of mathematics achievement (Children’s Defense Fund, 1994).

As instructional diversity continues to expand within classrooms across the country, educators are faced with a daunting task. Yet the science of learning is quite definitive with regard to essential instructional components that are necessary to enhance the academic performance of students. Unfortunately, without the
use of technology to do many of these tasks, teachers become less able to take on the challenges they face within the classroom on a daily basis.

The purpose of this study was to examine the effect on daily math instruction and student achievement of adding a computerized curriculum-based instructional management system to the classroom. Math performance was assessed on two separate measures and compared to similar students enrolled at the same school as well as randomly selected students from the district-wide testing database. In addition, during the course of the study, students were enrolled within classrooms where teachers implemented the math intervention with varying degrees of fidelity. Therefore, each analysis examined the level of the independent variable on overall performance. Finally, student outcomes were examined based on participation in the study relative to previous levels of performance as high, middle, and low performing math students. The comparison to a randomly-selected district-wide control group was carried out in an effort to control for nonrandom assignment of teachers (and thus students) to treatment. An analysis of covariance was used to control for nonrandom assignment of students to classes.

Overall, the findings of this study demonstrate positive outcomes for students enrolled in classrooms where teachers used the AM software. In fact, students enrolled in classrooms where teachers implemented the AM intervention to a greater degree benefitted the most. That is, student math performance was higher compared to both a within-school and a random sample of district students. Moreover, these observed math gains were significant for high, middle, and low performing students. Taken together, these findings suggest that if teachers are able to access information for each individual student in a timely manner, they may be better equipped to differentiate instruction and provide more instructional adaptations for students along the full performance continuum.

This study is important because it demonstrates the expanded impact curriculum-based management systems such as AM can have on enhancing student performance within an urban setting. As noted in the recent release of NAEP 2000, students in urban settings, specifically students of color, are the most vulnerable. Participating students in this study were approximately 75% students of color with 67% receiving free or reduced-price lunch. This intervention appears to identify one method of incorporating effective instructional techniques into a computer software package that if used appropriately can have a significant impact on accelerating the math achievement of students and more importantly, students along the full continuum of performance (high, middle, and low performing).

REFERENCES


