

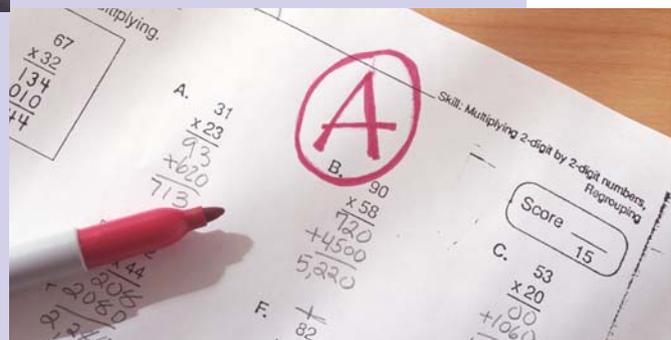
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# Using a Curriculum-Based Instructional Management System to Enhance Math Achievement in Urban Schools



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SPECIAL SCHOOL DISTRICT NO 1

 The College of Education  
& Human Development  
UNIVERSITY OF MINNESOTA

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

***Prepared By:***

Jim Ysseldyke • Richard Spicuzza<sup>1</sup> • Stacey Kosciolek • Ellen Teelucksingh • Christopher Boys • Amy Lemkuil  
*University of Minnesota*

<sup>1</sup> *Also with Research, Evaluation and Assessment, Minneapolis Public Schools*

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## Executive Summary

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Student 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 the instructional diversity continues to expand within classrooms across the country educators are faced with an increasingly 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 essentially unarmed to take on the challenge faced within the classroom on a daily basis.

The purpose of this study was to examine the effect of adding a computerized curriculum-based instructional management system within classrooms on overall student math achievement. Math performance was measured on two separate measures and compared to similar students enrolled at the same school as well as a random selection of students from an extant district 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 based on participation in the study relative to previous levels of performance as high, middle, and low performing math students was examined.

Overall, the findings of this study demonstrate positive outcomes for students enrolled in classrooms where teachers used the Accelerated Math™ (AM) software. In fact, students enrolled in classrooms where teachers implemented the AM intervention to a greater degree benefited 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. These findings suggest that if teachers are able to access information in a timely manner they may be better equipped to differentiate instruction and thus provide the instructional adaptations for students of all ability levels when necessary.

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## Overview

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Historically, the level of academic achievement for students in the United States has been a national concern (National Commission on Excellence in Education, 1983). 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, at eighth grade students from 20 countries outperform U. S. students, a finding that has reinforced concerns about math achievement. Overall, eighth graders in the U. S. scored higher than their international peers in only seven countries (U. S. Department of Education, 1998). At a national level, according to newly released National Assessment on Educational Progress (NAEP) data, only 26%, 27%, and 17% of fourth, eighth, and twelfth graders respectively were performing at or above the proficient level in math. The National Assessment Governing Board (NAGB) has identified the proficient level as one that *all* students should reach (Braswell, Lutkus, Grigg, Santapau, Tay-Lim, & Johnson, 2001).

An even more alarming statistic 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). It is clear that at multiple levels there continues to be an increasing need for students in this country to improve their math performance and achievement.

Since 1983, major academic and school reform strategies have been enacted to address these issues. School personnel have responded to concerns about low math achievement in numerous ways. Some of these responses include (1) writing or re-writing standards, (2) “ratcheting up” current standards, (3) building accountability systems that include all students, (4) developing new programmatic interventions, (5) extending the school year, and (6) implementing effective instructional management systems.

Fortunately, there have been some improvements in the math performance and achievement of students nationwide in the past decade. Reports issued on the 2000 National Assessment of Educational Progress indicate that the percentage of students scoring at or above the basic level has increased at all three grade levels by 19 %, 14%, and 7%, for grades 4, 8, & 12 respectively, compared to 1990 and 1996 assessment results (Braswell et al., 2001).

Despite these improvements 30% to 35% of 4<sup>th</sup>, 8<sup>th</sup>, and 12<sup>th</sup> graders are still performing at a “below basic” level (Braswell, et al., 2001). More specifically, at a national level, a large number of minority students in the U.S. and students in urban areas in particular, have plenty of room for improvement. For example, in the 2000 NAEP Math Assessment, Students of Color (primarily African-American and Hispanic/Latino) at three grade levels, 4<sup>th</sup>, 8<sup>th</sup>, and 12<sup>th</sup>, performed substantially lower than white American students. Moreover, these achievement gaps among

the various racial/ethnic groups have remained relatively unchanged since 1990 (Braswell et al., 2001). 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 within the area of math instruction has never been greater.

## **Evidenced-based Principles of Effective Instruction**

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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 the psychological literature (Brophy & Good, 1986; Christenson, Ysseldyke, & Thurlow, 1989; Walberg, 1984). As educators investigate instructional correlates of positive educational outcomes, the same core factors emerge. Walberg (1984) synthesized the results from thousands of studies on factors related to student outcomes and specified several instructional factors that had significant relationships to improved student outcomes. 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), Ysseldyke and Christenson (1992), and Ysseldyke and Christensen (in press) synthesized the literature on effective instruction and identified 12 critical instructional factors. These factors include: 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) provide 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 discuss 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 synthesis.

Collectively, these empirically demonstrated principles of learning, if effectively applied, increase

**Table 1. Evidence-Based Instructional Practices (Practices Shown Significantly Related to Improved Educational Outcomes)**

Effective and Efficient Classroom Management
A Positive Instructional Environment
Appropriate Match of Instruction to the Skill Level of Individual Learners
Clearly Stated Goals and Expectations
Clearly Presented and Delivered Lessons
Personalized Instruction
Instructional Support Differentiated for Individual Learners (Adaptive Instruction)
High Amounts of time Allocated to Instruction
High Amounts of Active Student Academic Engagement
High Amounts of Opportunity to Respond to Instruction
Active Monitoring of Student Progress and of Their Understanding of What is Being Taught
Direct and Frequent Measurement of the Outcomes of Instruction
Moderate to High Success Rates for Individual Students
Feedback on Student Performance and Reinforcement of Correct Performance
Cooperative Learning
Individualized Goal Setting

the probability for producing significant improvements in student outcomes (Carroll, 1963; Pressley, 1998; Walberg, 1984; Ysseldyke & Christenson, 1993). Unfortunately, translating research into practice is accompanied by many challenges. Although researchers have identified many instructional factors that are related to positive educational outcomes for students, incorporating them into a typical classroom of 25-35 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, provide 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.

## Two Especially Critical Factors: Instructional Match and Academic Learning Time

Research is quite definitive about the importance of matching academic assignments to individual students' abilities (Anderson, 1984; Christenson et al., 1989; Fleischner & Manheimer, 1997; Slavin & Madden, 1989; Walberg, 1984). One way to evaluate whether or not 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, & Williams, 1981; Gickling and Armstrong, 1978; Good and Grouws, 1975). With slight variations it is

commonly recommended that 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 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 (Borg, 1980; Fisher, Berliner, Filby, Marlieave, Cahen, & Dishaw, 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" (Fisher et al., 1980, p. 8). Thus, student engagement and rate of success become critically inter-related in understanding the science of student learning.

ALT is comprised of three basic components: (a) total amount of time allocated for instruction, (b) the student's academic engagement rate, and (c) 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; Hall, 1980; 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; Shinn, 1985). 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). 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 (Black, 1998).

## Curriculum-Based Management Systems

Recently one computer-based program, Accelerated Math™, developed by Renaissance Learning, Inc. (1998), has shown promise as a curriculum-based management system. It appears to incorporate many of the effective instructional principles noted earlier. Furthermore, 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 Accelerated Math software allows teachers to 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 unrealistic 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 that to date has been 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 Accelerated Math on student math performance in an urban district. In a study by Spicuzza and Ysseldyke (1999) the effects of this curriculum-based management system on student math performance were examined during a six-week summer school program in an urban district. Results indicated that students using Accelerated Math 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, Ysseldyke, Lemkuil, Kosciolk, Boys, and Teelucksingh (in press), the effects of Accelerated Math 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 Accelerated Math curriculum-based management system for English Language Learning students and found significant outcomes. Overall, the results of these studies collectively indicate that students who participated in Accelerated Math classrooms demonstrated more growth on measures of mathematics than students who did not participate.

## Limitations of Previous Research

While 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, to date most studies have been for limited periods of time. Thus, a likely extension

of this research would suggest examining the impact for 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 we examined the classroom level of implementation along with student outcomes.

The current study was designed to examine whether adding the use of a computer-based management system like Accelerated Math—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: (1) Does the use of Accelerated Math by educators lead to greater student math achievement compared to students not monitored using the assistance of technology that the Accelerated Math program provides? (2) Do students at various skills levels (e.g., high, middle, and low achieving students) demonstrate greater improvement in math achievement when teachers use Accelerated Math along with the district math curriculum? (3) To what degree does the integrity of implementation of Accelerated Math impact student math achievement?

## **Method**

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### **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 Accelerated Math™ intervention across the four sites. Demographic information is listed for the AM participants in Table 3. Students were enrolled in 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> grade with approximately equal numbers of male and female participants. Approximately 75% of the participants were students of color and receiving free or reduced 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 Accelerated Math program and training after obtaining principal support for participating in the study (see Table 4).

In addition to the participating students, two comparison groups were selected. 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 through 5) from three of the schools in which AM was used (see Table 3) (One participating site included all students in grades 3 to 5; therefore, no within-school comparison students were available.) A

**Table 2. Student 1999-2000 Site Demographics**

School	K	1	2	3	4	5	6	7	8	Total # Students	AI	AfA	AsA	HA	WA	Fr/Red	SpEd	ELL
<b>BM</b>	16% 78	15% 74	18% 86	18% 87	15% 73	16% 75	-	-	-	473	1% 4.73	39% 184.47	45% 212.85	1% 4.73	15% 70.95	80% 378.4	21% 99.33	42% 198.66
<b>JL</b>	13% 81	16% 99	7% 106	19% 117	18% 112	7% 102	-	-	-	617	3% 18.5	33% 203.6	38% 234.4	2% 12.3	25% 154.2	74% 456.6	13% 80.2	32% 197.4
<b>LF</b>	19% 48	18% 46	19% 50	15% 39	17% 43	12% 32	-	-	-	258	12% 30.9	49% 126.4	2% 5.16	4% 10.3	33% 85.1	74% 190.9	22% 56.7	19% 49.0
<b>E_SILC</b>	14% 73	14% 72	13% 66	13% 64	11% 55	9% 48	8% 45	8% 44	7% 39	506	4% 20.2	18% 91.1	1% 5.1	50% 253	26% 131.6	57% 288.4	6% 30.4	32% 161.9

**Coding Key:**

- K - Kindergarten
- 1 – 1<sup>st</sup> Grade
- 2 – 2<sup>nd</sup> Grade
- 3 – 3<sup>rd</sup> Grade
- 4 – 4<sup>th</sup> Grade
- 5 – 5<sup>th</sup> Grade
- 6 – 6<sup>th</sup> Grade
- 7 – 7<sup>th</sup> Grade
- 8 – 8<sup>th</sup> Grade

Total # Students – Total number of students in school

AI – American Indian

AfA – African American

AsA – Asian American

HA – Hispanic American

WA – White American

Fr/Red – Eligible for Free/Reduced Lunch

SpEd – Receiving Special Education Services

ELL – Receiving ELL Service

**Table 3. Student 1999-2000 Demographic Data**

	<b>AM Participants</b>	<b>AM Participants</b>			<b>Within School</b>	<b>Within School</b>			<b>District</b>	<b>District</b>		
		<b>L</b>	<b>M</b>	<b>H</b>		<b>L</b>	<b>M</b>	<b>H</b>		<b>L</b>	<b>M</b>	<b>H</b>
Total	397	35	65	62	484	27	28	56				
Gender												
Male	205	21	25	28	239	16	11	34				
Female	192	14	40	34	245	11	17	22				
Grade												
3	55	13	10	1	256	19	6	5				
4	164	12	27	27	114	6	11	18				
5	178	10	28	34	114	2	11	33				
Ethnicity												
Non-Minority	91				109	3	2	31				
Minority	306	27	51	33	375	24	26	25				
Lunch												
Full Price	103	4	14	28	156	2	7	34				
Free/Reduced	294	31	51	64	328	25	21	22				
Special Services												
ELL	125	9	26	13	149	17	15	3				
Sp. Educ.	45	7	3	2	50	7	0	4				

**Table 4. 1999-2000 Teacher Demographics**

<b>Total</b>	
Gender	18
Male	4
Female	14
<b>Integrity of Implementation (AM program)</b>	
None	0
Partial	8
Full	10

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 3.

## Degree of Classroom Implementation.

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. (Renaissance learning identifies specific pacing schedules for student’s to complete grade level libraries within an academic year. Model classroom standards range from 2-4 objectives per week.) 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 4). A description of the criteria for level of classroom participation is listed in Table 5.

**Table 5. 1999-2000 Criteria for Classroom Participation**

	<b>Mean Objectives Mastered</b>	<b>Mean Problems Attempted</b>
No Participation	0	0
Partial Participation	1-21	1-530
Full Participation	> 21	≥ 531

## 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 training and a copy of the Accelerated Math 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. Accelerated Math scores assignments and keeps records of student and class performance. It also provides information to teachers on individual and class-wide progress.

Teachers were trained on how to use the Accelerated Math software during a training session held in October 1999. The training session was conducted by 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 implementation of AM in their classroom. 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.

## **Achievement Measures**

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### **Northwest Achievement Levels Test (NALT)**

Each year, all students in this urban district in grades 2-7 are tested on the math portion of the Northwest Achievement Levels Test (Northwest Evaluation Association, 1998). 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 (Northwest Evaluation Association, 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 norms 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 Northwest Evaluation Association (NWEA) (Northwest Evaluation Association, 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 while there were fewer Black and Hispanic students than in the national population.

Reliability of the NALT was calculated during the 1995-96 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 (Northwest Evaluation Association, 1996). In order 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 (Northwest Evaluation Association, 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 districts annual math exam. Grade 2 district math scores had 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 (Advantage Learning Systems, 1998), a computer-adaptive test of math skills. This test was designed for use with students in grades 3 through 12 and measures skills in numeric concepts, computation, and math application. The test consists of 24 multiple-choice questions and students are allowed a maximum of 3 minutes 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 Accelerated Math program library assignment as previously noted. This test also provides information related to student growth in math performance using a pre-post-test design. Another feature of this computer-adaptive test is that it allows for continual monitoring of progress throughout an 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, while those who answer questions incorrectly are given an easier item. Essentially, the test is designed to focus in 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, suburban), gender, 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, while at the higher grades they are in the .80s. 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 (Advantage Learning Systems, Inc. 1998b).

All students in the AM participant group and comparison group participated in pre-testing on STAR Math in September 1999. All students completed a post-test 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**

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The performance of students participating in Accelerated Math 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 post-test scores on both the STAR and NALT measures.

## **Results**

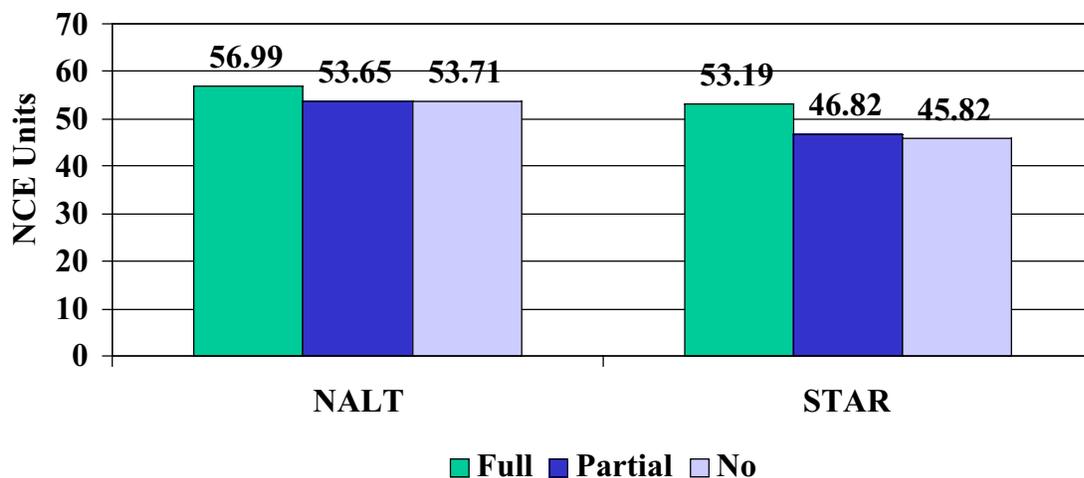
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### **Achievement: Within School Comparisons**

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 pre-test scores as the covariate and post-test scores as the dependent variable.

The results of the analyses for both the NALT and Star Math tests indicated a positive effect of the Accelerated Math treatment. Overall, students enrolled in classrooms classified as demonstrating 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 non-participant 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 non-participation group, for which the mean was 45.8 (see Figure 1).

**Figure 1. NALT and STAR Post-test Adjusted Mean by Level of Intervention**



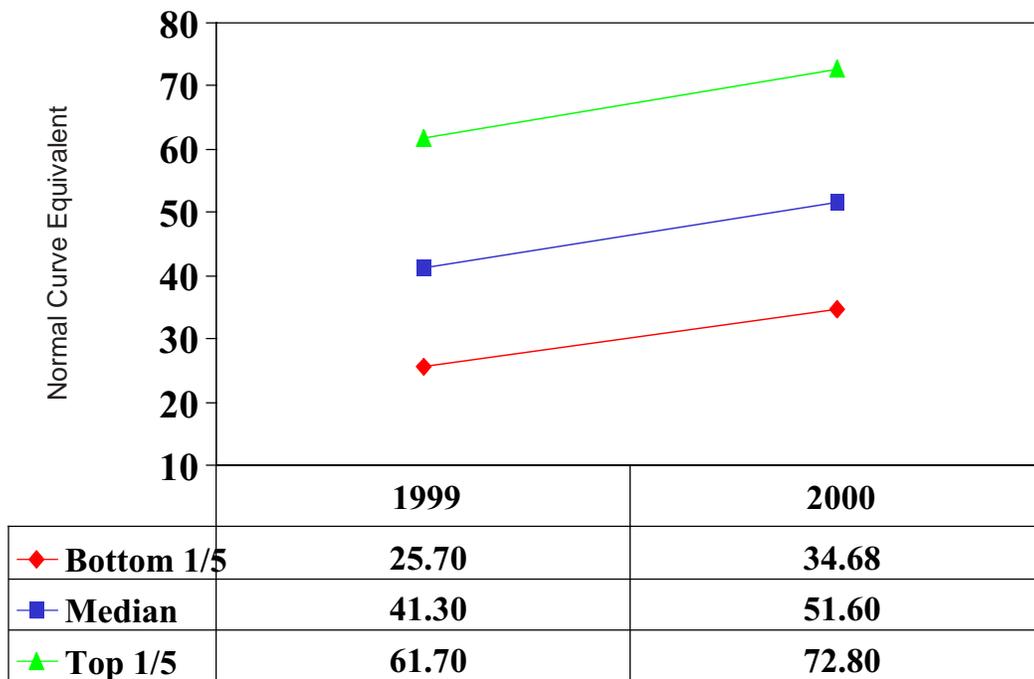
### Within School Comparison: High, Middle, and Low Performers.

In addition to statistical analyses comparing mean differences, we employed a 20/20 analysis, 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 (1/5<sup>th</sup>) 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 student who most clearly require adaptation in instruction that accounts for their exceptional status high-above or well-below grade level norms (Reynolds & Heistad). 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” such that only specific level of students are benefiting. 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.

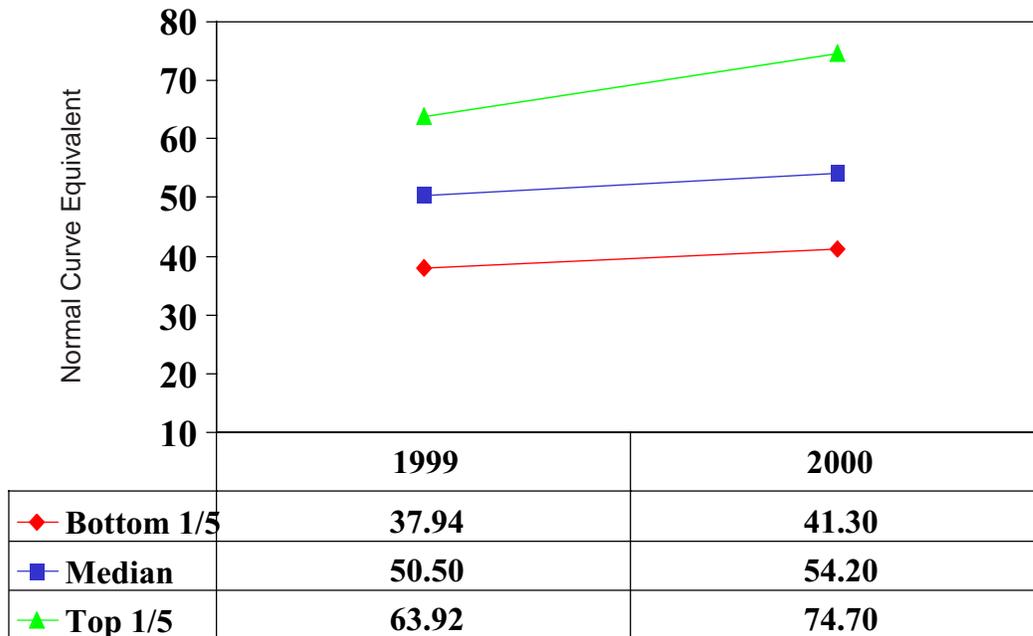
A 20/20 analysis is conducted by plotting the scores of students who perform at the top 1/5<sup>th</sup>, the median, and the bottom 1/5<sup>th</sup> of the sample. Issues related to regression to the mean are accounted for by plotting the NCE score that separates these points in the distribution at time one (pre-test) and then time two (post-test) 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.

**Figure 2. Star 20/20 Analysis Full Participation**



Normal Curve Equivalents (NCE) 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. NCE 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 (45<sup>th</sup> percentile Time 1 and the 45<sup>th</sup> percentile Time 2) the students' NCE growth would be zero (or a horizontal line on a graph).

**Figure 3. NALT 20/20 Analysis Full Participation**



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 also relative performance has improved across high, middle, and low performing students. Student performance 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 (80, 50, and 20<sup>th</sup> 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

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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. In addition, achievement gaps continue to be relatively stable between white students and students of color. 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 the 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 essentially unarmed to take on the challenge faced within the classroom on a daily basis.

The purpose of this study was to examine the effect of adding a computerized curriculum-based instructional management system within classrooms and to daily math instruction on overall student math achievement. Math performance was measured 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 based on participation in the study relative to previous levels of performance as high, middle, and low performing math students was examined.

Overall, the findings of this study demonstrate positive outcomes for students enrolled in classrooms where teachers used the Accelerated Math software. In fact, students enrolled in classrooms where teachers implemented the AM intervention to a greater degree benefited 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).

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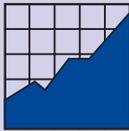
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