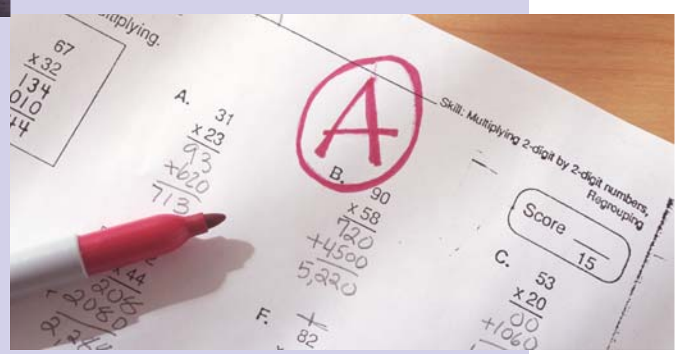
Classroom-Based Assessment Project

Effects of Using a Curriculum-Based Monitoring System on the Classroom Instructional Environment and Math Achievement



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The College of Education & Human Development
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Effects of Using a Curriculum-Based Monitoring System on the Classroom Instructional Environment and Math Achievement

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March 2001

Spicuzza, R., Ysseldyke, J. E., Lemkuil, A., Kosciolek, S., Boys, C., & Teelucksing, E. (2001). *Effects of using a curriculum-based monitoring system on the classroom instructional environment and math achievement*. Minneapolis, MN: University of Minnesota, National Center on Educational Outcomes.

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Executive Summary

During the second half of the 1998-99 school year, a large urban school district implemented Accelerated Math (AM), a curriculum-based monitoring system, to evaluate its effect on components of effective instruction and student achievement outcomes. Data were gathered on the instructional environment of participating students under two conditions: math instruction with the district curriculum alone, and math instruction with the district curriculum enhanced with AM. Achievement data were also gathered for the AM participants and for two comparison groups: students in the same schools and students in the rest of the district who did not use AM.

Based on a review of literature, Ysseldyke and Christenson (1993) suggest that there are specific instructional strategies and tactics that, if used in combination, are likely to increase student success (Table 1). In this study, we used The Instructional Environment System-II (TIES-II) to measure the presence these instructional components. TIES-II divides the measurement of the instructional ecology into four categories and twelve instructional components (Table 3).

The results indicated that overall, under the condition of Everyday Math alone, nine of the twelve effective instructional components measured were in place for the majority of the students. When Accelerated Math was added to math instruction, all twelve of the effective instructional components were in place for the majority of the students (Table 4). In both conditions, students with higher initial achievement levels had more components of effective instruction present (Table 5).

In addition to changes for the components overall, there were differences in the affect of AM on individual instructional components. In this implementation of AM there were many positive effects noted in the instructional categories of Delivery and Monitoring/Evaluation. The largest effects were found for Progress Evaluation, Informed Feedback, and Cognitive Emphasis. These positive effects were noted for high, average, and low achieving students.

First, adding AM increased the amount of students for whom Progress Evaluation was clearly present. Researchers have established positive relationships between monitoring student progress and student achievement outcomes (Denham & Lieberman, 1980; Fuchs, 1986). The AM computer software lends an accessible way of monitoring student progress. Also, given the nature of the software, the student automatically moves on to the next objective after they demonstrate mastery on the previous one. Without AM it is difficult to see whether teachers monitor the progress of student growth on curriculum objectives. Adding AM automates part of the process of evaluating progress toward mastery of the Everyday Math curriculum objectives that are also in the AM objective libraries.

Second, using Accelerated Math in the classroom increased the amount of Informed Feedback given to students. Brophy (1986) found that teachers who provide regular and extensive feedback to their students elicit higher achievement. As with Progress Evaluation, this component is

partially automated by the AM software. The computer prints a report after each assignment, detailing how the student performed on each skill. The student and the teacher must then review the report and make corrections. Providing these reports in the AM program allowed more students to get instructional feedback from the computer program and from the teacher.

Third, Cognitive Emphasis increased considerably when AM was added to math instruction. This component includes directly communicating thinking and learning strategies to students. Pearson and Dole (1985) have shown that explicit instruction can produce achievement gains. Specific feedback from teachers often included direct teaching of learning strategies related to particular skills. The Accelerated Math software gave teachers access to information on student performance that they used to determine which students needed direct teaching on which skills.

In two of the instructional categories, Planning and Management, no positive changes were noted when AM was added to instruction. For one of the components in the Planning category, Instructional Match, there was a decrease in the low achieving group. One possible explanation is that the lowest level of Accelerated Math libraries available at the time of this implementation was third grade. The observed students were in fourth and fifth grade. For low achieving students, especially in fourth grade, the third grade library may have been too high. The software company has since released objective libraries at the second and first grade levels. This decrease in Instructional Match may not have occurred had these libraries been available for this implementation. There was no increase overall for the other Planning component, Teacher Expectations. This component was present for 86% of the students in both conditions. It appears that teachers have high expectations for students with and without the use of Accelerated Math.

The instructional component in the Management category, Classroom Environment, showed a relatively large decrease in presence when AM was added to math instruction. The presence of a positive classroom environment decreased from 96% of the students when Everyday Math was used alone to 64% of the students when AM was added. The classroom environment component relates to classroom management, including established rules, procedures, and organizational routines that, in turn, should increase the amount of productive use of classroom time. In several of the classrooms, when AM was being used, there was less structure in the room. This was each teacher's first experience using AM. From field notes gathered by research assistants, teachers commented that they were continuously trying to improve classroom procedures and the integration of AM with their class routine. Teachers were still learning how to use the program and trouble-shooting problems that came up. This may have contributed to the appearance of less structure during the lesson when AM was used. Also the computers used in the classrooms were rather slow. At times, students would wait a few minutes before their TOPS report and next assignment was printed out. This may have influenced the data collectors rating of the presence of a positive classroom environment. As teachers learn the program and become better able to manage the many aspects involved, decreases in the classroom environment may disappear. Further, faster technology in the classroom may also improve this effect on classroom environment.

In addition to changes in the instructional environment, differences in achievement growth were also found between students who used Accelerated Math and students who did not. Low, average, and high achieving students in the participating schools who use the Everyday Math curriculum already make NCE unit gains on the district NALT test at or above what is expected throughout the school year in math (low = 4.4, average = 5.9, high = 1.4). However, students at all skill levels who used AM made even greater gains on the NALT compared to students who did not use AM (low = 8.1, average = 8.8, high = 3.5). Positive effects of using AM were also noted through student NCE gains on the Star math test (Comparison Group: low = -1.5, average = 3.2, high = -1.2; AM participants: low = 4.1, average = 6.0, high = 11.5).

Adding an instructional monitoring system such as Accelerated Math to a comprehensive curriculum, such as Everyday Math, has a positive effect. Students in this school district already receive several of the components of effective instruction during math and demonstrate positive gains on district achievement tests. However, when Accelerated Math, a curriculum-based monitoring system, was added to math instruction, more positive components were present for more students and achievement gains increased.

Overview

In recent years, the American public and educators have been concerned about the poor achievement of American students in math and science. Concerns about the math achievement of U.S. students are highlighted in the popular press, journal articles (Stedman, 1997), major conference presentations (Jones, et al., 1999; Gonzalez, Martin, & Mullis, 1999; Tananis, & van der Ploeg, 1999), and official U.S. Department of Education reports (1998). Fortunately, there have been some recent improvements in the area of math performance and achievement of students nationwide. According to data gathered from the National Assessment of Educational Progress (NAEP), the percentage of students scoring at or above the basic level on the 1996 mathematics assessment increased in all three grades: grade 4 (14%), grade 8 (10%), and grade 12 (11%) compared to the 1990 assessment results (Resse, Miller, Mazzeo, & Dossey, 1997).

Although there have been some improvements in students' math performance at a national level, students in the U.S. have much room for improvement at a global level. According to the Third International Mathematics and Science Study (TIMSS) in 1995, U.S. eighth graders scored below the 41-nation, international average in math. Eighth graders in 20 countries outperformed American eighth grade students, and eighth graders in the U.S. scored higher than their international peers in only seven countries (U.S. Department of Education, 1998). These findings clearly indicate that there continues to be an increasing need for students in this country to improve their math performance and achievement.

Improving the math achievement of students is a complex problem to which there are no simple solutions. Student achievement is affected by many factors, which are related to the individual, home, school, and larger community. Several authors have made suggestions on what schools can do to help improve student math performance in the United States. These suggestions have included paring down the number of topics covered in math and giving more in-depth attention to what is covered, creating more demanding curricula (Schmidt, McKnight, & Raizen, 1997), providing personal support to students, and changing instructional methods (Stedman, 1997).

In this study, we focused on enhancing teaching practices to improve math achievement at school. To accomplish this goal of increasing student math achievement, teachers need to use core effective instructional techniques that are well established in the research literature. There presently exists a wealth of educational research that identifies principles of effective instruction and learning (Caroll, 1963; Walberg, 1984; Ysseldyke & Christenson, 1993). Empirically demonstrated principles of learning, if effectively applied, should result in significant improvements in student outcomes (Carroll, 1963; Walberg, 1984; Pressley, 1998; Ysseldyke & Christenson, 1993).

Based on a review of literature, Ysseldyke and Christenson (1993) suggest that there are specific instructional strategies and tactics that, if used in combination, are likely to increase student success (Table 1). An essential goal of education is to find ways to incorporate these practices into instructional environments. For this to be accomplished, instructional arrangements should be in place that enable teachers to engage in behaviors that are related to positive student outcomes. In fact, a combination of many instructional features must be in place in the natural classroom environment to maximize student outcomes (Ysseldyke & Christenson, 1987).

Table 1. Instructional Factors Related to Improved Student Achievement Outcomes

Planning Procedures
- Sufficient time allocated to academic activities
- Quality teacher-diagnosis of student skill level
- Prescription of tasks that are matched to skill level
- Realistic, high expectations and academic standards
- Appropriate instructional decision-making (grouping, materials, ongoing diagnoses)
- Sufficient content coverage
- Instruction designed to include presentation, practice, application, and review
- Kind of curriculum (spiral vs. sequential)

Management Procedures
- Efficient classroom management procedures
- Well-established and efficient instructional organization and routines
- Productive use of instructional time
- Positive, supportive classroom interactions

Monitoring and Evaluation Procedures
- Active monitoring of seatwork activities
- High success rates (on daily and unit tests)
- Frequent, direct measurement of pupil progress
- Progress through the curriculum depends on mastery criteria
- Curriculum alignment (the relationship between what is to be taught [goals], what is taught [instruction], and what is tested [assessment])

Teaching Procedures
- Instructional sequence includes demonstration, prompting, and provision of opportunity for practice
- Expectations (goals, objectives, academic standards) are communicated clearly
- Lesson Presentation – Related Factors
  - Extensive substantive teacher-pupil interaction, teacher questioning, signaling, and re-explaining
  - Teacher-directed instruction (proceeding in small steps, careful structuring of learning experiences, etc.)
  - Clear demonstration procedures and systematic use of error correction procedures
  - High rate of accurate student response
  - Amount of guided practice prior to independent practice
  - Explicitness of task directions
- Practice – Related Factors
  - Amount and kind of independent practice
  - Appropriate seatwork activities
  - Systematic application of principles of learning to instruction
  - High rates of academic engaged time (academic learning time, opportunity to learn)
  - Brisk, fast pacing of curriculum and lesson
  - Degree of student accountability Systematic, explicit feedback and corrective procedures

Ysseldyke and Christenson (1987)

Unfortunately, translating research into practice is fraught with challenges (Odom, 1988). 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). Keeping up with each student individually to provide instruction that is motivating and appropriate to his or her skill level can be an impossible task.

A recently developed and released educational software product, Accelerated Math™, created by Advantage Learning Systems, Inc. (1998), provides a framework that may make it easier for teachers to maximize an effective instructional environment for each student. The Accelerated Math software program is a curriculum-based monitoring (CBM) system that allows teachers to manage multiple instructional tasks like matching instruction to students' skill level, providing appropriate practice, monitoring progress, and providing feedback on performance. According to the developers, Accelerated Math is a flexible program that can be integrated with an array of textbooks, curricula, instructional materials, and philosophies of instruction. What this CBM system brings to the classroom is the automation of the tasks of scoring, record keeping, and assigning practice. It gives the teacher a quick way of obtaining summarizing information about student work on specific skill areas. Using this information management system to automate some of the busy work of teaching, teachers may be better able to incorporate instructional practices that are linked to improved student outcomes.

In a previous study, Ysseldyke, Spicuzza, & McGill (2000) found that the implementation of the curriculum-based monitoring system, Accelerated Math, was related to changes in student behavior, in that students' academic engaged time went up. Further, students whose teachers used AM along with the regular curriculum showed greater increase in performance on math achievement tests.

In this study, we examined the effect of using this curriculum-based monitoring system on students' instructional environment. We wanted to learn the extent to which using the program would allow teachers to enhance the instructional environment of the classroom.

The purpose of the current study was to monitor changes in the presence of components of effective instruction under two instructional conditions. In the first condition, Condition One, math instruction consisted of using the Everyday Math curriculum only. Condition Two included Everyday Math enhanced with Accelerated Math. Three research questions were pursued: (1) Does the use of Accelerated Math in combination with Everyday Math lead to increases in the use of components of effective instruction? (2) Are the effects on the instructional environment different for high, middle and low achieving students? and (3) Do students in each skill level (high, middle, and low) demonstrate greater improvement in math achievement when teachers use Accelerated Math along with Everyday Math?

Method

Participants

Participants in this study were part of a larger multiple-grade project being conducted at four elementary schools in a large urban school district in the Midwest from February to June of 1999. Nine classrooms were selected to participate in the implementation of AM based on the classroom teachers' willingness to participate in the study. At school #1, four classrooms participated, at school #2, three classrooms participated, and one classroom was involved at school #3 and school #4. The total number of students in the participant group was 205. These classrooms used AM along with the Everyday Math curriculum.

From the participant group, a subgroup of 24 students in the fourth and fifth grades was selected for participation in our collection of data on changes in the instructional environment. These students were selected from eight participating classrooms to represent three different levels of math achievement (i.e., high, middle, and low performance). We selected students based on their performance on the STAR Math exam administered in December of 1998. One high-achieving student (Percentile Rank (PR) >= 80), one middle-achieving student (PR between 40 and 60), and one low-achieving student (PR< 20) were selected from eight of the participating classrooms. There were four classrooms that did not have any students who scored at or above the 80th percentile. For these classes, all three students were chosen based on their ranking on the test compared to other students in the class.

In addition to the participating students, two comparison groups of students were selected. Math performance was compared among intervention students and the two comparison groups. The first comparison group (C1) consisted of 184 students from three of the schools in which AM was used. The students in this within-school comparison group did not use Accelerated Math during the school year. A second comparison group (C2) was selected from the rest of the district. Performance information on the district administered NALT test for all continuously enrolled students in second through seventh grade was gathered from the district 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.

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. As

Table 2. Demographic Characteristics of Participants

		AM Participants N=205	AM Participants Observed Students High N=7	Middle N=8	Low N=7	Comparison Group (within-school) N=184	Comparison Group (district) N=15,502
Gender	Male	100	5	4	4	99	7789
	Female	105	2	4	3	85	7713
Grade	3	0	0	0	0	0	3471
	4	71	4	4	4	71	3328
	5	111	3	4	3	38	3220
	6	5	0	0	0	45	2808
	7	10	0	0	0	16	2675
	8	8	0	0	0	14	0
Ethnicity	Minority	168	5	5	7	116	10,660
	Non-Minority	37	3	3	1	68	4842
Lunch Program	Full Price	43	2	1	0	54	4986
	Free/Reduced	162	6	7	8	130	10,516
Services	ELL[a]	54	3	0	0	34	2715
	Sp. Educ. [b]	33	0	0	1	30	2156

[a] ELL - English Language Learner
[b] Sp. Educ. - Special Education

with most curricula, teachers must use curriculum materials as well as their own set of instructional strategies to convey this information to students.

Intervention

Accelerated Math is a curriculum-based monitoring system that helps teachers assign appropriate practice to students and monitor student progress toward mastery of various math objectives. The software program focuses on the practice of foundational math skills and on providing immediate feedback regarding student performance to both the student and the teacher. Accelerated Math has 12 standard libraries of math objectives, ranging from grade three through calculus. The company has recently expanded to include libraries for first and second grade. However, these two libraries were not available at the time of this implementation. Each student works in a library that is matched to his or her individual achievement level. The program creates 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, 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 December 1998. The session was conducted by a trainer from the Institute for Academic Excellence, a sub-company of Advantage Learning Systems. In addition to this training session, a graduate research assistant was assigned to each school to check in 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 varied by teacher.

Instructional Ecology Measure

In this study, we used The Instructional Environment System-II (TIES-II) to measure the presence of effective instructional components identified by Ysseldyke and Christenson (1987). TIES-II uses a multi-method, multi-source approach to data collection and measurement of the instructional environment experienced by individual students (Ysseldyke & Christenson, 1993). Measurement of the classroom instructional environment is divided into four major categories and twelve components within the categories. The four major categories are Planning, Management, Delivery, and Monitoring/Evaluation. Descriptions of the twelve components are given in Table 3.

Instructional environment data were collected for each student under two separate instructional conditions. Condition one involved math instruction using Everyday Math alone. Condition two consisted of math instruction using Everyday Math with Accelerated Math. For both conditions in this study we collected data using three of the TIES-II data forms: the Student Observation Record, a student interview created based on the Student Interview Record, and the Instructional Environment Form.

The TIES-II Student Observation Record is an anecdotal observation form that the observer uses while observing an individual student during a classroom lesson. Observers record their observations of the student in relation to the four major instructional categories. The student interview we used for each student was based on the TIES-II Student Interview Record. Questions on this interview asked students to think about math instruction and answer several questions related to their confidence in math, their attitude toward math, the time spent working on math assignments at home and school, their understanding of math assignments, and the type of feedback they receive from their teacher about math. Finally, for each condition, the TIES-II Instructional Environment Form was used to synthesize the information gathered for each student from observations and interviews. On this form the data collector answered questions about the extent to which each of the 12 instructional components was present for each student.

Data collection on the instructional environment for condition one (Everyday Math alone) was conducted during January and February, before the classrooms started using the Accelerated Math program. Each of the students in the observation group was observed during Everyday

Table 3. The Instructional Environment System-II (TIES-II)

Instructional Planning

1. Instructional Match – the student's needs are assessed accurately, and instruction is matched appropriately to the results of the instructional diagnosis.
2. Teacher Expectations – There are realistic, yet high, expectations for both the amount and accuracy of work to be completed by the student and these are communicated to the student.

Instructional Management

3. Classroom Environment – The classroom management techniques used are effective for the student; there is a positive, supportive classroom atmosphere; and time is used productively.

Instructional Delivery

4. Instructional Presentation – Instruction is presented in a clear and effective manner, the directions contain sufficient information for the student to understand the kinds of behaviors or skills that are to be demonstrated, and the student's understanding is checked.
5. Cognitive Emphasis – Thinking skills and learning strategies for completing assignments are communicated explicitly to the student.
6. Motivational Strategies – Effective strategies for heightening student interest and effort are used with the student.
7. Relevant Practice – The student is given adequate opportunity to practice with appropriate materials and a high success rate. Classroom tasks are clearly important to achieving instructional goals
8. Informed Feedback – The student receives relatively immediate and specific information on his/her performance or behavior; when the student makes mistakes, correction is provided.

Instructional Monitoring/Evaluation

9. Academic Engaged Time – The student is actively engaged in responding to academic content; the teacher monitors the extent to which the student is actively engaged and redirects the student when the student is unengaged.
10. Adaptive Instruction – The curriculum is modified within reason to accommodate the student's unique and specific instructional needs.
11. Progress Evaluation – There is direct, frequent measurement of the student's progress toward completion of instructional objectives; data on the student's performance and progress are used to plan future instruction.
12. Student Understanding – The student demonstrates an accurate understanding of what is to be done and how it is to be done in the classroom.

Math instruction. Trained data collectors conducted observations across multiple days for a total of 40-58 minutes for each student. Students were not aware that they were being observed. During January and February, the data collectors also interviewed students. After the interview and observation data were collected, the data collector used this information to fill out the Instructional Environment Form for each student.

After classrooms began implementing the Accelerated Math program in conjunction with

Everyday Math instruction, instructional environment data were collected again. The data for condition two were collected from the end of February through May. As in the data collection for condition one, each student was observed for a total of about one-hour across multiple days and was interviewed by the data collector. After interview and observation data were complete, the data collector filled out an Instructional Environment Form for each student.

Achievement Measures

Northwest Achievement Levels Test

Every year, all second through seventh grade students in the participating district are tested on the math portion of the Northwest Achievement Levels Test (NALT) (Northwest Evaluation Association, 1998). The NALT: Mathematics Test is a series of eleven achievement tests that measure student performance in basic skill areas of mathematics. Each student takes a paper and pencil, group administered mathematics test that is appropriate for their skill level. The appropriate level test is determined for each student by previous performance on the NALT or a locator test. Some of the areas included in the tests are number sense, measurement, relations, functions, randomness, and data investigation. Results are reported in RIT scores (scale scores) and percentile ranks.

All students in the experimental and comparison groups were tested on the NALT along with other students in the district under the standard procedures employed by the district each year. Results are reported as the change from spring 1998 to 1999 as measured in Normal Curve Equivalent units (NCE).

Star Math Test

Students in this study were also evaluated using the Star Math exam (Advantage Learning Systems, 1998b), a computer-adaptive test of math skills. Star Math is designed for use with grades 3 through 12 and measures skills in numeric concepts, computation, and math application. The test is a "branching test" in which the actual items administered depend on student performance throughout the test. Each student works at their own pace and the test ends when the student has responded to a total of 24 questions. This generally takes between 15 and 20 minutes. The Star Math test is used for two purposes. It is used to place each student at the appropriate level in the AM program. It is also used as a post-test to determine student growth. The test provides grade equivalents, percentile ranks, scaled scores, and NCE units, based on national norms.

All students in the AM participant group and the within-school comparison group participated in pre-testing on Star Math in December 1998. All students completed a post-test on Star Math at the end of the school year (May/June 1999). Students were tested in computer labs under the supervision of their teacher or lab assistants. Results are reported as the change from pre-to post-testing in Normal Curve Equivalent (NCE) units.

Analyses

Two qualitative analyses were completed using the information from the Instructional Environment Forms for each condition. First, we examined changes in the presence of instructional components from condition one to condition two for all students together. Next, we separated students by skill level and examined changes across conditions for each group.

Two analyses were conducted on the achievement data. For each analysis, we measured outcomes in terms of the change in Normal Curve Equivalent (NCE) scores between pre-test and post-test performance on math achievement measures. NCE scores are calculated based on the normal curve and have equal intervals between each unit. They have a mean of 50 and a standard deviation of 21. NCE units can be used in statistical analysis and to compare scores between students and between tests at any point on the test performance continuum, as well as across time. Students in Chapter I schools generally gain 1-3 NCE units when comparing their performance across an entire calendar year (Slavin, Karweit, & Madden, 1989). NCE gains of more than 3 points in Spring-to-Spring or Fall-to-Fall comparisons typically are considered educationally significant.

For the first analysis, we compared the NALT performance of students who participated in Accelerated Math to the NALT performance of all the same-grade students in the rest of the district. To get an idea of the performance of students across skill levels, we performed a 20/20 analysis. In this analysis, we selected the top 20%, the median 20% and the bottom 20% of students in the AM participant group and compared the change in their performance with the top 20%, median 20%, and bottom 20% of students within the same grade range in the rest of the district. The procedures for 20/20 analyses are described and recommended by Reynolds and Heistad (1997).

The second achievement analysis was conducted using performance on both the NALT and the Star Math tests. In this analysis, we compared the performance of students who used AM to the performance of students within the same schools who did not use AM. Again, we selected the top 20%, the median 20%, and the bottom 20% of performers on each test for each comparison.

Results

Instructional Ecology

The purpose of the study was to monitor changes in the presence of components of effective instruction under two instructional conditions. TIES-II was used to investigate whether there was a qualitative change in the instructional ecology for students when a curriculum-based monitoring system, Accelerated Math, was added to math instruction. The presence of instructional components related to positive student academic outcomes during condition one (Everyday math only) was compared to the presence of these components during condition two (Everyday Math with Accelerated Math). In addition, TIES-II was used to analyze the presence of these components in the two conditions for high, average, and low achieving students.

Specific research questions included: (1) Does the use of Accelerated Math in combination with Everyday Math lead to increases in the use of effective instructional components? and (2) Are the effects on the instructional environment different for high, middle, and low achieving students?

Due to prolonged student absences, complete data (observation and interview data for both conditions) were collected for 22 of the 24 students in the observation group.

Instructional Components

Differences for All Students

To address the first research question, the frequency in which raters noted the presence of each instructional component was tallied for each student for each condition. Data for students at all achievement levels were aggregated. The results of this analysis for all students are detailed in Table 4

In this implementation of Accelerated Math, there were no positive changes noted in the categories related to planning and managing instruction. These categories consist of three components: Instructional Match (work is neither too easy nor too frustrating), Teacher Expectations (there are realistic, yet high, expectations of students), and Classroom Environment (the classroom is managed so there is a positive atmosphere and time is used productively). These three components were already present for over 80% of students before AM was added. According to the data collectors, the number of students for whom these components were present either went down or did not change when AM was added to Everyday Math instruction. (Instructional Match, Condition one = 18 students, Condition two = 17 students; Teacher Expectations, both conditions = 19 students; Classroom environment, Condition one = 21 students, Condition two = 14 students.)

There were several positive changes noted in the categories of Delivery and Monitoring/ Evaluation instruction. During condition one, EM alone, data collectors noted that two components in the Delivery category, Cognitive Emphasis and Informed Feedback, were present for less than 41% of the students. Data collectors noted the presence of these two components

Table 4. Number and Percent of Students with Ecological Components Present for Condition 1 and Condition 2

	Condition 1 (EM only)		Condition 2 (EM w/AM)		Difference	
Instructional Component	SA/A*	%	SA/A	%	SA/A	%
Planning						
1. Instructional Match	18	81.8	17	77.3	-1	-4.5
2. Teacher Expectations	19	86.4	19	86.4	0	0.0
Management						
3. Classroom Environment	21	95.5	14	63.6	-7	-31.9
Delivery						
4. Instructional Presentation	17	77.3	16	72.7	-1	-4.5
5. Cognitive Emphasis	7	31.8	17	77.3	+10	+45.5
6. Motivational Strategies	15	68.2	17	77.3	+2	+9.1
7. Relevant Practice	20	90.9	19	86.4	-1	-4.5
8. Informed Feedback	9	40.9	19	86.4	+10	+45.5
Monitoring/Evaluation						
9. Academic Engaged Time	15	68.2	16	72.7	+1	+4.5
10. Adaptive Instruction	15	68.2	19	86.4	+4	+18.2
11. Progress Evaluation	1	4.5	20	90.9	+19	+86.4
12. Student Understanding	20	90.9	19	86.4	-1	-4.5

* SA/A – Strongly agree or agree

for considerably more students when AM was added to EM instruction (Cognitive Emphasis, Condition one = 7 students, Condition two = 17 students; Informed Feedback, Condition one = 9 students, Condition two = 19 students). The three other components in the Delivery category were noted as present for more than 68% of students before AM was added. The presence of Motivational Strategies increased for two students (condition one = 15, condition two = 17). Small decreases were noted for Instructional Presentation (condition one = 17, condition two = 16) and Relevant Practice (condition one = 20, condition two = 19).

A positive influence of Accelerated Math was more notable in the Monitoring/Evaluation components. The most striking change was the increase in the data collectors' indication of the presence of Progress Evaluation from one student when EM was used alone, to 20 students when AM was added to EM. Other positive, but less drastic, changes were noted for Adaptive Instruction (from 15 students to 19 students) and Academic Engaged Time (from 15 students to 16 students). One component in this category did show a small decrease. Student Understanding was noted as present for 20 students in condition one and for 19 students in condition two.

Overall, during condition one, nine of the twelve effective instructional components were present for the majority of students. During condition two, all twelve effective instructional components were present for the majority of students. Positive changes were noted for several of the components in the Delivery and Monitoring/Evaluation categories. There were no positive changes in the Planning and Management categories.

Differences for High, Middle, and Low Achieving Students

In the second analysis, changes in instructional components across time were evaluated to see if these varied for high, middle, and low achieving students. Four of the instructional components changed in the same direction for students at each skill level. The presence of an effective Classroom Environment decreased across all three groups, and increases in the presence of Cognitive Emphasis, Informed Feedback, and Progress Evaluation were noted in each skill group. Results are summarized in Table 5.

For the other seven effective instructional components, changes were different for students at different skill levels. Instructional Match, Motivational Strategies, and Student Understanding

Table 5. High, Middle, and Low Achieving Students with Instructional Components Present for Condition One (EM only) and Condition Two (EM with AM)

	High Achieving (N=7)		Middle Achieving (N=8)		Low Achieving (N=7)	
Instructional Component	EM only	EM w/AM	EM only	EM w/AM	EM only	EM w/AM
Instructional Match	100* 7**	100 7	87.5 7	87.5 7	57.1 4	42.9 3
Teacher Expectations	100 7	85.7 6	87.5 7	87.5 7	71.4 5	85.7 6
Classroom Environment	100 7	85.7 6	100 8	50 4	85.7 6	57.1 4
Instructional Presentation	100 7	71.4 5	75 6	75 6	57.1 4	71.4 5
Cognitive Emphasis	57.1 4	85.7 6	12.5 1	87.5 7	28.6 2	57.1 4
Motivational Strategies	85.7 6	100 7	62.5 5	75 6	57.1 4	57.1 4
Relevant Practice	100 7	85.7 6	87.5 7	100 8	85.7 6	71.4 5
Informed Feedback	42.9 3	85.7 6	50 4	87.5 7	28.6 2	85.7 6
Academic Engaged Time	71.4 5	85.7 6	75 6	75 6	57.1 4	57.1 4
Adaptive Instruction	57.1 4	85.7 6	62.5 5	87.5 7	85.7 6	85.7 6
Progress Evaluation	0 0	100 7	0 0	100 8	14.3 1	71.4 5
Student Understanding	100 7	100 7	100 8	100 8	71.4 5	57.1 4

* - Percent of students for whom the instructional component was marked present
** - Number of students for whom the instructional component was marked present

all decreased in presence among the low achieving students. Each of these either went up or stayed the same for the middle and high achieving students. Academic Engaged Time increased for low achieving students and stayed the same for the middle and high achieving students. There was a positive increase noted for low achieving students in the presence of the components appropriate Teacher Expectations and appropriate Instructional Presentation, while the presence of these components stayed the same for students with middle and high skill levels. The presence of Adaptive Instruction increased for high and middle achieving students, and stayed the same for low achieving students. Finally, Relevant Practice increased for middle achieving students and decreased for low and high achieving students.

In summary, large positive increases in the presence of three of the effective instructional components were not isolated to one skill level group. Also, the decrease in effective Classroom Environment was seen for students regardless of skill level. There were different effects for various skill levels for components that showed smaller changes from condition one to condition two. In addition, when comparing high, average, and low achieving students under both conditions, high achieving students experience more instructional features identified as components of effective instruction as measured by TIES-II.

Achievement

In addition to examining changes in the instructional environment when AM is added to math instruction, we assessed changes in achievement as well. For the first achievement analysis, we used a 20/20 analysis, an analysis restricted to students whose achievement is in either the top 20% or bottom 20% on a pretest, to compare the NALT performance of the students in the project who participated in Accelerated Math to the NALT performance of all students in similar grades in the rest of the district. Only students for whom complete data were available were included in the analysis. NCE scores and gains for the district and for the AM participant group are shown in Table 6. Students throughout the district showed gains as expected or lower than expected on the NALT. Students in all three skill levels who participated in AM showed gains either as expected or higher than expected. On average, the gains made by the middle and low achieving students were over twice those made on average by middle and low achieving students in the rest of the district.

In the second analysis, we compared achievement gains on both the NALT and Star Math test for students who used AM and for students within the same schools who did not use AM. On the Star Math test, students with low, middle, and high skills who used Accelerated Math all made gains that were higher than expected: 4.1, 6.0, and 11.5 respectively (Figure 1). In contrast, the students in the same schools who did not use Accelerated Math did not show as much growth overall on the Star Math test. A decline in performance was noted for students at the

Table 6. Normal Curve Equivalent Scores on the NALT for the Entire District and for Accelerated Math (AM) Participants

	District (N=15,502)			AM Participants (N=187)		
	NALT 1998 (Pre NCE)	NALT 1999 (Post NCE)	*Gain*	NALT 1998 (Pre NCE)	NALT 1999 (Post NCE)	*Gain*
Top 1/5	70.9	70.9	*0.0*	64.2	67.7	*3.5*
Median	46.3	48.9	*2.6*	43.6	52.4	*8.8*
Bottom 1/5	28.2	31.5	*3.3*	26.3	34.4	*8.1*

bottom 20% of students (-1.5 NCE units) and students at the top 20% (-1.5 NCE units). Students in the middle 20% of the distribution displayed more than expected growth (3.5 NCE units) (Figure 2).

On the NALT measure, gains were also observed at all three levels of student performance for students who participated in Accelerated Math (Figure 3). Students at the top 20% who participated in AM gained 3.5 NCE units. Those in the middle 20% gained 8.8 NCE units. Finally, students at the bottom 20% gained 8.1 NCE units. Gains on the NALT for students in the same schools who did not participate were lower at each skill level (Figure 4). The top 20% gained 1.4 NCE units, the median gained 6.2 NCE units, and the bottom 20% of students gained 4.4 NCE units.

Figure 1. Star Math 20/20 Analysis for Students who Participated in Accelerated Math

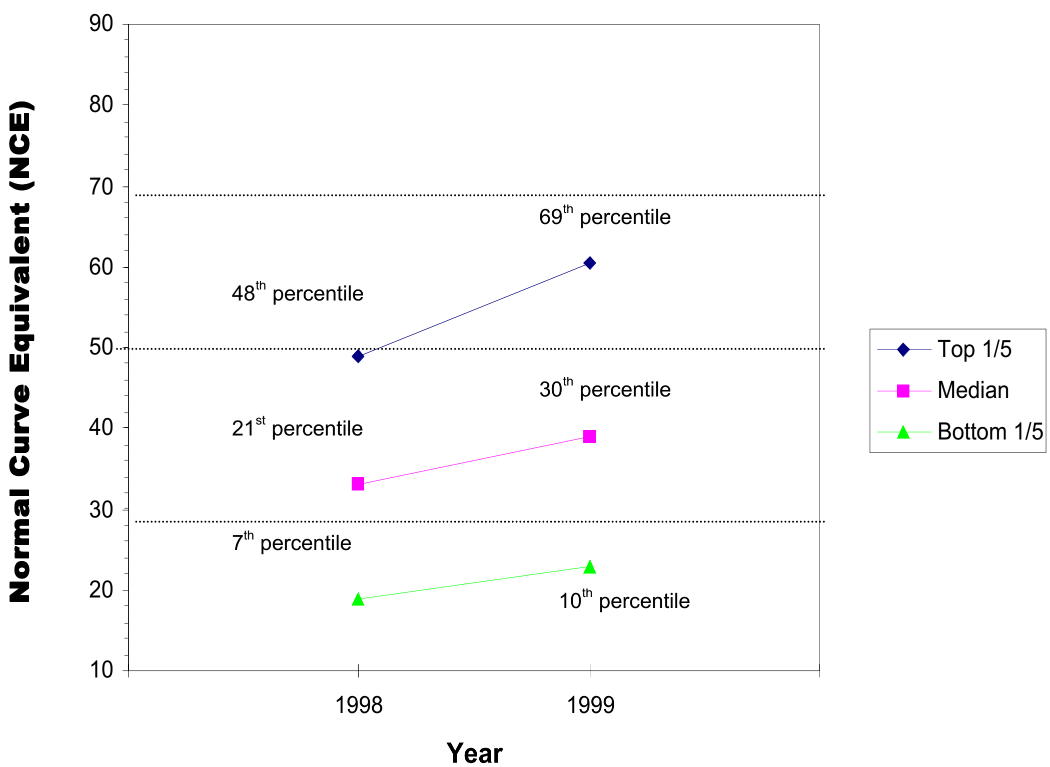


Figure 2. Star Math 20/20 Analysis for the Within-School Comparison Group

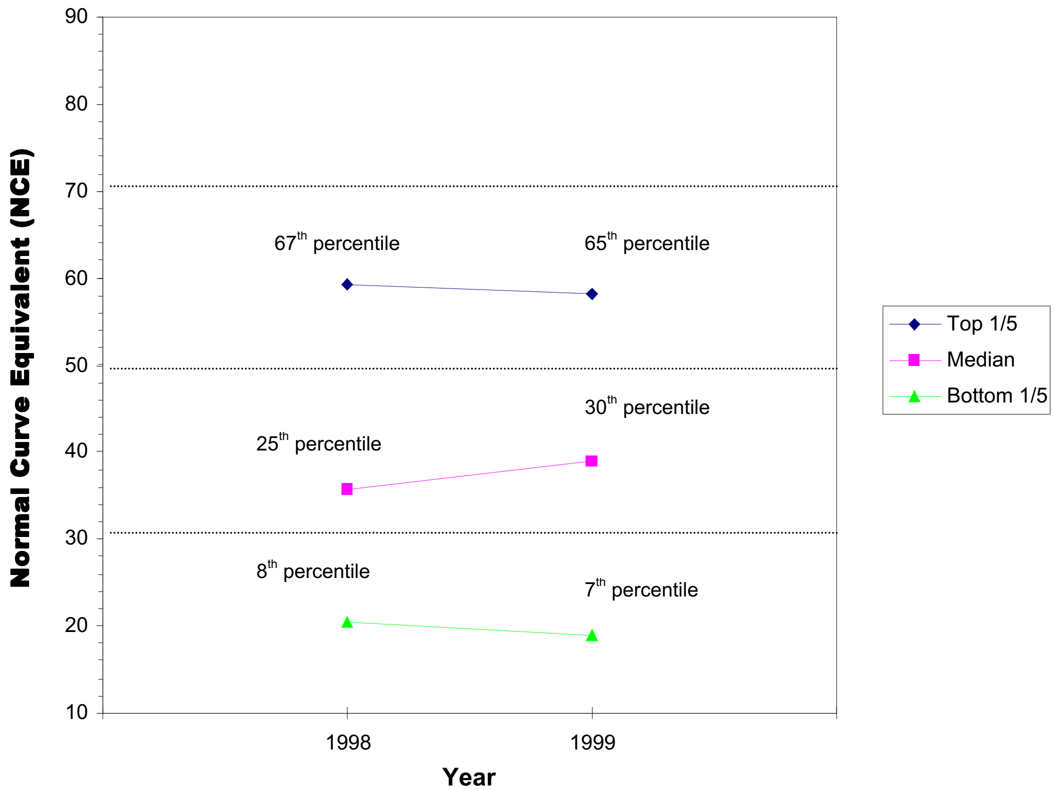


Figure 3. NALT 20/20 Analysis for Students Who Participated in Accelerated Math

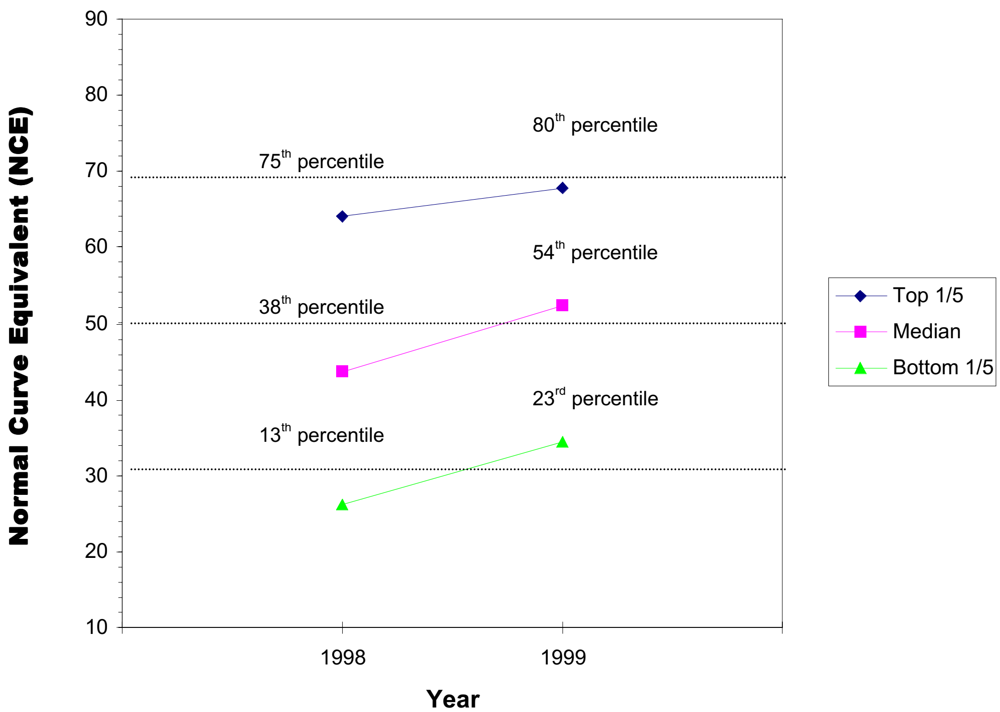
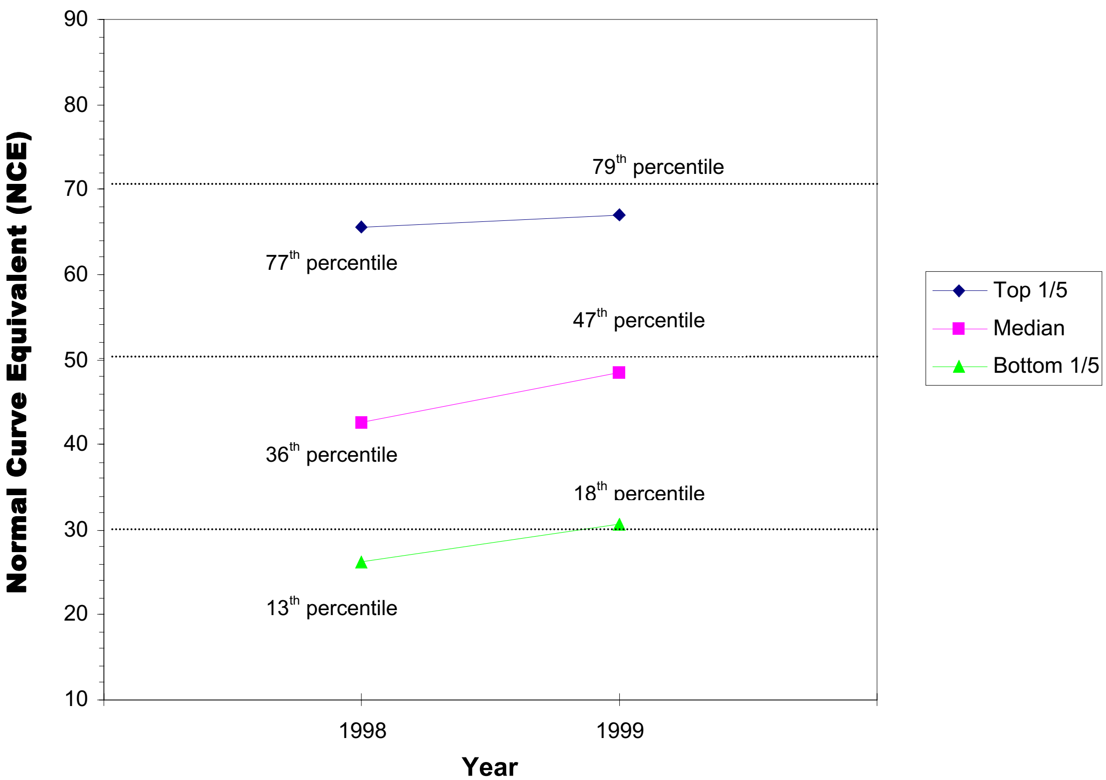


Figure 4. 20/20 NALT Analysis for the Within-School Comparison Group



Discussion

Accelerated Math, a curriculum-based monitoring system, provides a framework for specifically altering the instructional environment of the classroom. It is well known that increasing effective instruction in the instructional environment will lead to improved student outcomes (Ysseldyke & Christenson, 1993). Accelerated Math is designed to support the instructional repertoire of teachers, allowing them to draw upon computer technology to facilitate the incorporation of effective instructional components into their classroom.

During the winter school year, a large urban school district implemented the Accelerated Math program to evaluate its effect on components of effective instruction and student achievement outcomes. Data were gathered on the instructional environment of participating students under two conditions: math instruction with the district curriculum alone, and math instruction with the district curriculum enhanced with Accelerated Math. Achievement data were also gathered for the group of students who participated with Accelerated Math and for two comparison groups: students in the same schools, and students in the rest of the district who did not use AM.

Three specific questions were examined: (1) Does the use of Accelerated Math in combination with Everyday Math lead to increases in the use of effective instructional components? (2) Are the effects on the instructional environment different for high, middle, and low achieving students? and (3) Do students in each skill level demonstrate greater improvement in math achievement when teachers use Accelerated Math along with Everyday Math?

Our analysis of the changes in instructional environment addressed the first two questions. Overall, under the condition of Everyday Math alone, nine of the twelve effective instructional components were in place for 68% or more of the students. When Accelerated Math was added to math instruction, eleven of the effective instructional components were in place for 68% or more of the students. In both conditions, students with higher initial achievement levels had more components of effective instruction present.

In addition to changes for the components overall, there were differences in the affect of Accelerated Math on individual instructional components. In this implementation of Accelerated Math there were many positive effects noted in the instructional categories of Delivery and Monitoring/Evaluation. The largest effects were found for Progress Evaluation, Informed Feedback, and Cognitive Emphasis. These positive effects were found for all three skill groups observed across time. Accelerated Math also showed a positive effect on Adaptive Instruction. However, this effect was smaller and experienced by high and middle achieving students. There was no change in the amount of adaptive instruction for low achieving students.

First, adding AM increased the amount of students for whom progress evaluation was clearly present. Positive relationships between monitoring student progress and student achievement outcomes have been established (Denham & Lieberman, 1980; Fuchs, 1986). The AM computer software lends an accessible way of monitoring student progress toward the completion of instructional objectives. Also, given the nature of the software, the student automatically moves on to the next objective after they demonstrate mastery on the previous one. Without AM it is difficult to see whether teachers monitor the progress of student growth on curriculum objectives. Adding Accelerated Math automates part of the process of evaluating progress toward mastery of those Everyday Math curriculum objectives that overlap with those found in the Accelerated Math objective library.

Using Accelerated Math in the classroom also increased the amount of Informed Feedback given to the student. Brophy (1986) found that teachers who provide regular and extensive feedback to their students elicit higher achievement. As with Progress Evaluation, this component is partially automated by the AM software. The computer prints a report after each assignment, detailing how the student performed on each skill in the assignment. The student and the teacher must then review the report and make corrections. Also, the teacher has the option of printing other reports that summarize student performance. From these reports they can identify the students that need instruction on specific objectives. Providing these reports in the AM program allowed more students to get informed feedback pertaining to skill performance from the computer program and from the teacher.

The third component that increased considerably when accelerated Math was added to math instruction was Cognitive Emphasis. This component includes directly communicating thinking and learning strategies to students. Pearson and Dole (1985) have shown that explicit instruction can produce achievement gains. Specific feedback from the teachers often included direct teaching of learning strategies related to particular skills. The Accelerated Math software gave teachers access to information on student performance that they used to determine which students needed direct teaching on which skills.

The fourth component on which implementation of Accelerated Math had a positive effect was Adaptive Instruction. It appears that with the availability of individualized practices, teachers were able to adapt their instruction more to individual learners. Several other components in the Delivery and Monitoring/Evaluation categories showed small changes in both the negative and positive directions. However, these changes only affected one or two students.

In two of the instructional categories, Planning and Management, no positive changes were noted after the implementation of Accelerated Math. In the Planning category, one of the components, Instructional Match, went down by one student, and the component, Teacher Expectations, showed no change. The decrease in Instructional Match was seen in the low achieving group. One possible explanation is that the lowest level of Accelerated Math libraries available at the time of this implementation was third grade. The observed students were in fourth and fifth grade. For low achieving students, especially in fourth grade, the third grade library may have been too high. The software company has since released objective libraries at the second and first grade levels. This decrease in Instructional Match may not have occurred had these libraries been available for this implementation. There was no increase overall in Teacher Expectations. This component was present for 19 students in both conditions. It appears that teachers have high expectations for students with and without the use of Accelerated Math.

The instructional component in the Management category, Classroom Environment, showed a relatively large decrease in presence when Accelerated Math was added to math instruction. The presence of a positive classroom environment decreased from 21 students when Everyday Math was used alone to 14 students when Accelerated Math was added. The classroom environment component relates to classroom management, including established rules, procedures, and organizational routines that, in turn, should increase the amount of productive use of classroom time. In several of the classrooms when Accelerated Math was being used, there was less structure in the room. This was each teacher's first experience using Accelerated Math in his or her classroom. From field notes gathered by research assistants, teachers commented that they were continuously trying to improve classroom procedures and the integration of AM with their normal class routine. Teachers were still learning how to use the program and trouble-shooting problems that came up. This may have contributed to the appearance of less structure during the lesson when AM was used. Also, the computers used by the classroom were rather slow. At times students would wait a few minutes before their TOPS report and next assignment were printed out. This may have influenced the data collectors rating of the presence of a positive classroom environment. As teachers learn the program and become better able to manage the many aspects involved, decreases in the classroom environment may disappear. Further, faster technology in the classroom may also improve this effect on classroom environment.

In general, the instructional environment components most positively affected by the use of Accelerated Math in the classroom relate to the delivering and monitoring/evaluating of instruction. Essentially, this program allowed teachers to receive information regarding the students' understanding of certain foundational math skills, and adjust practice and instruction based on each students' individual growth.

In addition to changes in the instructional environment, differences in achievement growth were also found between students who used Accelerated Math and students who did not. Students in this school district, using the Everyday Math curriculum, already make gains on the district test at or above what is expected throughout the school year in math. This is apparent especially for middle and low achieving students, who gain 2.6 and 3.3 NCE units respectively. Students in Title I schools make between 1-3 NCE unit gains over the course of one year (Slavin, Karweit & Madden, 1989). However, when Accelerated Math is added to their math instruction, the gains they make are even larger. On the NALT greater gains were seen for this group at all skill levels (high = 3.5, middle = 8.8, and low = 8.1).

When looking at students within the same school and across different tests, there is more information about the effects of Accelerated Math on student math achievement. The difference in gains between students who used AM and those who did not are more pronounced for the Star math test than for the NALT; the same company that created the Accelerated Math program developed the Star math test. There is a greater overlap between what is encountered by students on AM practice assignments and what appears on the Star Math test. The benefit that students get from using the Accelerated Math program is more directly measured by the Star Math test. Therefore, differences on this test between students who use AM and those who do not would be, as expected, large and easier to demonstrate. Students who used AM also showed a greater improvement in math achievement on the NALT, although not as dramatic. Nonetheless, students on average—at all skill levels—benefited more from math instruction when Accelerated Math was added to Everyday Math on both the district NALT and the Star Math test.

Conclusion

Students in this school district already receive several of the components of effective instruction during math. They also demonstrate positive gains on achievement tests, with lower achieving students showing the highest gains on district tests. However, when Accelerated Math, a curriculum-based monitoring, system, is added to math instruction, these gains increase. Further, with the use of AM in the classroom, more students, regardless of skill level, experience more components of effective instruction. Specifically, the components that increase the most relate to the delivering, monitoring, and evaluating of instruction.

Adding instructional monitoring systems such as Accelerated Math to a comprehensive curriculum, such as Everyday Math, enhances student math achievement. In this implementation of Accelerated Math, there was a positive effect on the instructional environment experienced by students, as well as on the math achievement growth demonstrated by students on two math achievement tests. As the education of our children is a complex social issue, solutions will not be simple. However, drawing on technological advances to facilitate the teacher's task of providing effective instruction to all students is one of several necessary steps in the right direction.

References

Advantage Learning Systems, Inc. (1998a). *Accelerated Math* (Computer Program). Wisconsin Rapids, WI: ALS. (http://www.advlearn.com).

Advantage Learning Systems, Inc. (1998b). *STAR Math users manual*. Madison, WI: Advantage Learning Systems.

Brophy, J. E. (1986). Teacher influences on student achievement. *American Psychologist, 41*, 1069-1077.

Carroll, J. B. (1963). A model of school learning. *Teachers College Record, 64*, 723-733.

Denham, C. H., & Lieberman, A. (Eds.) (1980). *Time to learn.* Washington, DC: National Institute of Education.

Fuchs, L. S. (1986). Monitoring progress among mildly handicapped pupils: Review of current practices and research. *Remedial and Special Education, 5*(7) 5-12.

Gonzalez, E., Martin, M., & Mullis, I. (1999). *Research findings from TIMSS*. Presentation conducted at the NCSSO - 29th Annual National Conference on Large-Scale Assessment, Snowbird, Utah.

Jones, L., Mitchell, K., Pellegrino, J., Wise, L., Forgione, P., & Truby, R. (1999). *Grading the nation's report card: A forum on the National Academy of Sciences NAEP Evaluation.* Presentation conducted at the NCSSO - 29th Annual National Conference on Large-Scale Assessment, Snowbird, Utah.

Odom, S. L. (1988). Research in early childhood special education. In S. L. Odom & M. B. Karns (Eds.) *Early intervention for infants and children with disabilities: An empirical base.* (pp. 1-21). Baltimore: Brookes Publishing.

Pearson, P. D., & Dole, J. A. (1985). *Explicit comprehension instruction: The model, the research, and the concerns.* Paper presented at the American Educational Research Association, Chicago.

Pressley, M. (1998). *Reading instruction that works: The case for balanced teaching*. New York: Guilford Press.

Resse, C. M., Miller, K. E., Mazzeo J., & Dossey, J. A. (1997). *NAEP 1996 Mathematics Report Card for the Nation and the States*. Washington, DC: National Center for Education Statistics.

Reynolds, M., & Heistad, D. (1997). 20/20 Analysis: Estimating school effectiveness in serving students at the margins. *Exceptional Children, 63*(4), 439-449.

Schmidt, W. H., McKnight, C. C., & Raizen, S. A. (1997). *A splintered vision: An investigation of U. S. science and mathematics instruction*. Boston: Kluwer Academic Publishers.

Slavin, R., Karweit, N., & Madden, N. (1989). *Effective programs for students at risk*. Boston: Allyn and Bacon.

Stedman, L. C. (1997). International achievement differences: An assessment of a new perspective. *Educational Researcher, 26*(3), 4-15.

Stipek, D. J. (1996). Motivation and instruction. In D. C. Berliner & R. C. Calfee (Eds.). *Handbook of educational psychology*. New York: Simon & Schuster Macmillan.

Tananis, C., & van der Ploeg, A. (1999). *TIMSS in the classroom*. Presentation conducted at the NCSSO - 29th Annual National Conference on Large-Scale Assessment, Snowbird, Utah.

U. S. Department of Education. (1998). *The condition of education 1998* (Publication No. NCES 98-103). Washington, DC: National Center for Educational Statistics.

Walberg, H. J. (1984). Improving the productivity of America's schools. *Educational Leadership, 41*(8), 19-27

Ysseldyke, J., & Christensen, S. (1987). Evaluating students' instructional environments. *Remedial and Special Education, 8*(3), 17-24.

Ysseldyke, J., & Christensen, S. (1993). *The Instructional Environment System-II: A system to identify a student's instructional needs*. Longmont, CO: Sopris West.

Ysseldyke, J., Spicuzza, R., & McGill, S. (2000). *Changes in mathematics achievement and instructional ecology resulting from implementation of a learning information system*. Minneapolis, MN: University of Minnesota, National Center on Educational Outcomes.

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