Use of an Instructional Management System to Improve Mathematics Skills for Students in Title I Programs

JIM YSSELDYKE, JOE BETTS, TERI THILL, AND EILEEN HANNIGAN

ABSTRACT: A curriculum-based instructional management system was used to enhance the mathematics instruction of 3rd through 6th grade Title I and non-Title I students. Improvements in math achievement for Title I students who were and were not participants in this curriculum enhancement were also compared. Title I students who participated in the instructional management system significantly outperformed those who did not. There were also important qualitative differences in how the instructional management system worked for Title I and non-Title I students. Implications for managing math instruction are specified.

Key Words: Accelerated Math (AM), progress monitoring, Title I

It has been reported that American students have consistently fallen behind students from other industrialized countries in mathematics (Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996; Reese, Miller, Mazzeo, & Dorsey, 1997). Long-term trend data from the National Assessment of Educational Progress (NAEP) have indicated a widening gap between high and low poverty level scores from the 1980s to 1999 (U.S. Department of Education, 2001a). In mathematics, the gap between the two groups widened from a 20-point difference in 1986 to a 29-point difference in 1999 (U.S. Department of Education, 2001a). However, when looking at the data for low-achieving students (defined as those scoring at less than the 25th percentile on the math portion of NAEP) there have been increases in performance over time (U.S. Department of Education, 2001a).

Title I of the U.S. Elementary and Secondary Education Act (ESEA) was originally conceived as a part of the "War on Poverty" and its extension to academic opportunities for all children. The primary purpose and goal has stayed relatively stable over time: To ensure equal educational opportunities to all children and attempt to close the achievement gap between economically distant students by providing resources to schools serving disadvantaged students (U.S. Department of Education, 2001a). It continues under the most recent reauthorization (Public Law 107-110, The No Child Left Behind Act) to provide funding to schools in high-poverty areas to support improvements in teaching and learning in an

Jim Ysseldyke is a Birkmaier Professor of Educational Leadership and Associate Dean for Research and Joe Betts is a research assistant in the Department of Educational Psychology at the University of Minnesota, Minneapolis. Teri Thill and Eileen Hannigan are research analysts at Renaissance Learning, Inc., Madison, Wisconsin.

attempt to offer high-level services that help disadvantaged children succeed in school.

In the past, Title I and its predecessor, Chapter 1, were used by schools to provide targeted, remedial instruction. Much of the instruction used a pull-out model where students were taken out of their classrooms for short periods of time for remediation (O'Day & Gross, 1999). In general, it is argued that the instruction was not linked to a set of challenging content areas or to a set of high standards for academic achievement. Moreover, Title I primarily focused on teaching reading—with inadequate attention given to mathematics.

Schools may use Title I funds for a variety of educational interventions. For example, they may invest in tutoring or purchasing software and necessary hardware for enhancing basic skills instruction. Under the No Child Left Behind Act they may also use the funds for supplemental instruction. It has been reported that approximately 76% of the expenditures has been used for instructional purposes, 12% for instructional support, and 12% for program administration (U.S. Department of Education, 2001b). The federal resources provided by Title I are supposed to be used to help schools develop strategies to improve instruction and thus benefit students in their opportunities to excel in all academic areas, but an emphasis is placed specifically on reading and mathematics.

LeTendre, Wurtzel, and Bouckris (1999) provide a few good examples of Title I programs that have been actively trying to implement and manage a successful reform of mathematics learning. They indicate that the most effective math programs involve challenging curriculum and instructional materials, intensive and ongoing professional development, time for planning and collaboration, and the use of mathematics specialists and master teachers. Among the curricular innovations they list include the purchase and effective use of technology, and opportunities for extended learning time in math. School personnel face significant challenges in implementing technological innovations.

We know what works in instructing students who are designated as at-risk due to disadvantaged backgrounds. However, it is usually quite challenging to implement the components of effective instruction and to manage math learning experiences, especially in settings in which students have very diverse math skills. There are many summaries of components of effective instruction (Algozzine & Ysseldyke, 1992; APA, 1997; Walberg, 1984; Ysseldyke & Christenson, 1987, 2002; Ysseldyke & Elliott, 1999), and a general conclusion that the components of effective instruction are similar for most students. In Table 1, we have listed the components of effective instruction as identified by Ysseldyke and Christenson (2002). These are consistent with components identified by Carroll (1963) and Walberg (1984).

TABLE 1. Instructional Support for Learning Components for FAAB

Instructional planning: Decisions are made about what to teach and how to teach the student. Realistic expectations are communicated to the student.

- *Instructional match:* The student's needs are assessed accurately, and instruction is matched appropriately to the results of the instructional diagnosis.
- *Instructional 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 clearly to the student.

Instructional managing: Effective instruction requires managing the complex mix of instructional tasks and student behaviors that are part of every classroom interaction. This means making decisions that control and support the orderly flow of instruction. To do this, teachers make decisions about classroom rules and procedures, as well as how to handle disruptions, how to organize classroom time and space to be most productive, and how to keep classrooms warm, positive, and accepting places for the student with different learning preferences and performances.

- *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 delivering: Decisions are made about how to present information, as well as how to monitor and adjust presentations to accommodate individual differences and enhance the learning of the student.

- *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.
- *Cognitive emphasis:* Thinking skills and learning strategies for completing assignments are communicated explicitly to the student.
- *Motivational strategies:* Effective strategies for heightening student interest and effort are used with the student.
- *Relevant practice:* The student is given adequate opportunity to practice with appropriate materials and achieve a high success rate. Classroom tasks are clearly important to achieving instructional goals.
- *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 evaluating: Effective instruction requires evaluating. Some evaluation activities occur during the process of instruction (i.e., when teachers gather data during instruction and use those data to make instructional decisions). Other evaluation activities occur at the end of instruction (e.g., when the teacher administers a test to determine whether a student has met instructional goals).

- *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.
- *Adaptive instruction:* The curriculum is modified within reason to accommodate the student's unique and specific instructional needs.
- *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.
- *Student understanding:* The student demonstrates an accurate understanding of what is to be done and how it is to be done in the classroom.

Mathematics is an instructional area in which opportunity to learn has a direct effect on achievement. Math skills are not developed in isolation but are developed through undertaking challenging problems and, at times, comprehending complex ideas. This does not usually happen by accident. It must be planned, directed, and used as a direct function of teaching. Yet, mathematics teachers face daily challenges in using scarce resources to address the needs of students, particularly those who are disadvantaged and those who demonstrate diverse academic skills.

The law requires that Title I services be linked to the rigorous academic content and performance standards that are expected of all children. It also requires that aligned assessments measure students' progress toward these standards and that schools develop school-wide approaches to improve students' performance. About half of the Title I participants currently receive mathematics assistance. Instructors offer the math assistance in regular education classes that enroll an incredibly diverse group of students. In our work, we have shown that in a "typical" 6th grade class in a large urban school district there is a range of math performance of 9.5 years. Teachers need access to an instructional management program that will help them meet the needs of such diverse groups of students in single settings.

We conducted this study in an attempt to ascertain whether teacher use of a curriculum-based instructional management system focusing on managing mathematics instruction would enhance math outcomes for students in low-SES schools.

Accelerated Math™ (AM) is a curriculum-based instructional management system for mathematics (Renaissance Learning, 1998a). It is based on a number of what are called "Renaissance Learning Principles" that match nicely to the components of effective instruction identified by APA (1997), Carroll (1963), Christenson and Ysseldyke (2002), and Walberg (1984). These include assessment of student skill level and provision of instruction matched to skill level, personalized goal setting, provision of significant amounts of practice time, and provision of direct and immediate feedback to students and teachers on the students' performance. AM incorporates the evidence-based principles of effective instruction we listed in Table 1 and has been found to be effective in enhancing instructional outcomes for diverse students in elementary school settings (Spicuzza, Ysseldyke, Lemkuil, Kosciolek, Boys, & Teelucksingh, 2001; Ysseldyke & Tardrew, 2002).

Spicuzza et al. (2001) implemented AM as an enhancement to the Everyday Math (SRA/McGraw Hill, 1998) curriculum in a large urban school district. The use of AM led to improved math achievement and increased the frequency with which components of effective instruction known to enhance achievement were present in students' instruction. Ysseldyke, Spicuzza, Kosciolek, and Boys (2003) also found that implementation of AM led to students spending more time on classroom activities that have been identified as contributing to positive academic outcomes. Students who participated in the program demonstrated significantly higher gains in math achievement than students who did not.

In a large nationwide experiment, we previously examined the extent to which the use of AM enhanced achievement outcomes for students in Grades 3–10 in 67 classrooms in 47 schools in 24 states (Ysseldyke & Tardrew, 2002). Students who participated in AM interventions as an enhancement to the regular mathematics instruction they were receiving in their general education classes consistently demonstrated significantly higher math achievement gains than students in those same math programs who did not receive the AM enhancement.

Purpose

We sought to ascertain the extent to which teacher use of a curriculum-based instructional management system (Accelerated Math™) as an instructional enhancement that enabled them to monitor student progress and adapt math instruction would result in significantly greater gains in mathematics achievement for students in Title I programs than for Title 1 students whose teachers did not use a curriculum-based instructional management system. Given previous findings that this intervention was very effective for students in general, we wanted to examine its impact on the performance of students who are in Title I programs. In addition, we examined qualitative features of achievement, including variability among and between Title 1 and non-Title 1 students in the intervention on such indicators as practice items completed, percent correct on practice items, tests completed and percent correct on tests, objectives mastered, and objectives mastered in the major instructional library to which students were assigned.

Accelerated Math (AM)

AM™ (Renaissance Learning, 1998) is a curriculum-based instructional management system that helps teachers assign instruction that is matched to the skill development of the learner while also helping to monitor students' progress toward mastery of math objectives. AM provides students with instant feedback on their performance. It also gives the teacher printouts showing the progress of all students in the class, and it provides information about what to teach and how to match instruction to the level of skill development of the learner. In short, it makes it easier for the teacher to manage math instruction.

AM allows students the opportunity to work at a self-selected pace and the opportunity to develop mathematics skills at an individualized pace. AM has 12 standard libraries of math objectives, ranging from Grade 3 through Calculus. Each student works in a library that is matched to his or her individual skill level.

AM is a software program that creates individualized practice assignments for students using an Algorithm Problem Generator. This allows each student to work on assignments at his or her own instructional level with a continuous supply of new problems and assignments. Students work at their seat on math practices printed by the program, and then scan their completed answers into the computer. AM scores assignments and keeps records of student and class performance. It also provides information to teachers on individual and class-wide progress, and gives teachers diagnostic reports that help them pinpoint student difficulties and develop interventions to address them.

Method

We used a two-group pretest, posttest comparison approach to evaluate the hypothesis that students in Title I programming (n = 132), whose teachers use the mathematics instructional management system, will show greater gains in mathematics achievement than similar students in a Title I program (n = 138) who received no intervention other than their regular math instruction. An analysis of covariance method (ANCOVA) was used to evaluate differences at posttest and determine whether or not gains were significant while controlling for status on pretest results.

We followed the two-group comparison with an analysis of differences between the experimental (n = 132) and a control group (n = 600; non-Title I students who participated in AM) on qualitative aspects of the math instructional management intervention. We looked specifically at the extent to which the groups differed in the number of math problems they attempted, the percent of math problems they answered correctly, the number of tests they took and their percent correct on the tests, the number of math objectives they mastered, and the number of objectives they mastered in the major library they were working in.

Participants

The two groups of students who participated in this study were a subset of the 2,202 students who participated in the large national comparison. The groups were made up of all students who were classified as being in Title I programs in the states in which they were enrolled. In addition, we conducted comparisons of Title 1 (n = 132) and non-Title 1 students (n = 600) who participated in the instructional management system intervention. Demographic data on the participants in this study are shown in Tables 2 and 3.

Measurements

STAR Math (Renaissance Learning, Inc., 1998b) is a computer adaptive test of mathematics skills designed to be used with Grades 3–12. It measures mathematics skills in relation to numeric concepts, computation, and math applications. The test uses an adaptive branching algorithm to adjust the test to the level of the student's ability. On the average it takes approximately 15 minutes for a student to respond to the 24 items. Performance on STAR Math is correlated moderately high and as would be expected with performance on the mathematics subtests of major achievement tests like the California Achievement Test, Iowa Tests of Basic Skills, and the Metropolitan Achievement Test.

This test was used to assign pretest scores and posttest scores to all 101 students in the study. It also provided a suggested starting position on the AM intervention for the intervention group. The posttest outcomes scores were used to ascertain the level of growth each student obtained during the length of the project.

Results

We conducted an analysis of covariance (ANCOVA) comparing the gain in math achievement for Title 1 students who did and did not participate in the instructional management program. The R-squared value using posttest Normal Curve Equivalents (NCEs) with pretest NCE as a covariant was 0.438. There was a significant difference between groups ($p < .0001$). Students in the experimental group gained 7.9 NCEs whereas those in the control group gained 0.3 NCE, a difference in gain of 7.6 NCEs. The effect size (Cohen's d) was 0.5. The treatment had a significant effect on student gains in math achievement.

The second analysis we conducted was an ANOVA comparing the implementation factors for Title 1 (n = 132) and non-Title 1 students (n = 600) who participated in the curriculum-based instructional management system. Data on these comparisons are reported in Table 4. There was no difference between groups in the number of practice items they attempted or in the number of test problems they attempted. There were significant differences between these groups in average percent correct on practice items and test items, and in the number of math objectives they mastered. All differences were significant at $p < .0001$ and favored the non-Title 1 students.

TABLE 2. Demographics for Title I Experimental and Control Students in Grades 3 Through 6

		Grade										
		3		4		5		6		Total		
Race	Gender	C	AM	C	AM	C	AM	C	AM	C	AM	All
Asian	Males	0	0	0	0	0	0	1	0	1	0	1
	Females	0	0	0	0	0	0	0	0	0	0	0
African American	Males	2	3	1	5	0	1	0	1	3	10	13
	Females	1	2	5	3	0	0	1	0	7	5	12
Hispanic	Males	6	8	0	0	0	0	1	3	7	11	18
	Females	7	4	0	0	0	0	6	5	13	9	22
Native American	Males	0	0	0	0	0	0	0	0	0	0	0
	Females	0	1	0	0	0	0	0	0	0	1	1
White	Males	11	9	24	20	13	15	5	11	53	55	108
	Females	10	11	18	16	15	5	11	8	54	40	94
Unspecified	Males	0	0	0	1	0	0	0	0	0	1	1
	Females	0	0	0	0	0	0	0	0	0	0	0
Totals		37	38	48	45	28	21	25	28	138	132	270

TABLE 3. Demographic Data for Non-Title I Students Who Participated in AM

Race	Gender	Grade 3	4	5	6	Total
Asian	Males	1	3	1	0	5
	Females	1	0	0	0	1
African American	Males	4	6	7	1	18
	Females	3	1	7	1	12
Hispanic	Males	6	4	0	1	11
	Females	1	6	0	2	9
Native American	Males	1	10	0	0	11
	Females	0	7	0	1	8
Whites	Males	49	89	98	28	264
	Females	56	96	89	33	274
	Unspecified	0	0	0	1	1
Unspecified	Males	11	0	2	0	13
	Females	10	0	0	0	10
	Unspecified	0	0	23	0	23
Totals		143	222	227	68	660

TABLE 4. Analysis of Variance Statistics for Title I Students on Select Accelerated Math Implementation Factors

	Number of students	Number of practice problems attempted	Average % correct on practices	Number of test problems attempted	Average % correct on tests
Title I students	132	562	78.1	282	84.8
Non-title I students	660	534	82.2	314	88.8
Difference		28	–4.1	–32	–4
F		0.7	23.8	2.2	37.9
Significance		.415	< .001	.142	< .001

Discussion

Implementation of a curriculum-based instructional management system enhanced the math achievement of Title 1 students. Students in the experimental condition gained significantly more than those Title 1 students in the control condition. And, the gains were achieved over a 5-month intervention. The effect size for difference between groups was 0.5. Use of an instructional management system resulted in significant gains in math achievement.

Title I students attempted about as many practice problems and test items as non-Title I students. However, the non-Title 1 students demonstrated significantly more accurate performance.

The math achievement gains evidenced by students in Grades 3–6 are consistent for both non-Title I and Title 1 students. As school personnel search for ways to supplement or enhance the instruction of Title I students under the provisions of the No Child Left Behind Act, they should consider use of instructional management systems like Accelerated Math.

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