

MATHWINGS

Effects on Student Mathematics Performance

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The Center

Every child has the capacity to succeed in school and in life. Yet far too many children, especially those from poor and minority families, are placed at risk by school practices that are based on a sorting paradigm in which some students receive high-expectations instruction while the rest are relegated to lower quality education and lower quality futures. The sorting perspective must be replaced by a “talent development” model that asserts that all children are capable of succeeding in a rich and demanding curriculum with appropriate assistance and support.

The mission of the Center for Research on the Education of Students Placed At Risk (CRESPAR) is to conduct the research, development, evaluation, and dissemination needed to transform schooling for students placed at risk. The work of the Center is guided by three central themes — ensuring the success of all students at key development points, building on students’ personal and cultural assets, and scaling up effective programs — and conducted through four research and development programs and a program of institutional activities. CRESPAR is a partnership of Johns Hopkins University and Howard University.

CRESPAR is supported by the National Institute on the Education of At-Risk Students (At-Risk Institute), one of five institutes created by the Educational Research, Development, Dissemination and Improvement Act of 1994 and located within the Office of Educational Research and Improvement (OERI) at the U.S. Department of Education. The At-Risk Institute supports a range of research and development activities designed to improve the education of students at risk of educational failure because of limited English proficiency, poverty, race, geographic location, or economic disadvantage.

Abstract

Constructivist approaches to mathematics instruction based on the standards of the National Council of Teachers of Mathematics (NCTM) have been widely advocated and are expanding in use. However, many educators express a need for constructivist approaches that provide specific student materials, assessments, teachers' manuals, professional development, and other supports to enable a broad range of teachers to succeed with a broad range of children. MathWings was designed to accomplish this goal. MathWings provides a practical, comprehensive approach based on the NCTM standards.

Evaluations involving 19 schools have examined the impact of MathWings. This is every school that has implemented MathWings starting in 1998 or earlier and is in a state that has had a consistent math assessment over that time period. One evaluation found that the gains of seven North Carolina schools were substantially greater than those of other North Carolina schools on the state's End-of-Grade tests. Another evaluated six schools in California, which also showed outstanding gains in comparison to the state as a whole on the SAT-9. A study involving four rural schools in Maryland found substantially greater gains on the mathematics sections of the Maryland School Performance Assessment Program for MathWings students than for the rest of the state. A San Antonio study also found substantial gains on the Texas Assessment of Academic Skills math scale in grades 3-5 from 1996 (the year before the program began) to 2000. In 1999 and 2000, virtually every child passed TAAS-Mathematics. Finally, a study found substantial gains at all grade levels on state accountability measures in a majority-Navajo school in Page, Arizona, which started more than 23 percentage points below its state mean at pretest (1998) and almost reached the state mean in 2000.

Acknowledgments

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Introduction

The teaching of mathematics in the early elementary grades is in the midst of a revolution. This revolution goes under many names, but the name most often attached to it is constructivism. Constructivist mathematics teaching emphasizes *understanding* rather than algorithms (Carpenter et al., 1994; Davis, Maher, & Noddings, 1990). It begins with problem solving and “authentic” complex tasks, rather than building up from arithmetic. For example, children in kindergarten can figure out how many busses are needed to get the class to a picnic long before they learn any division algorithm. They can figure out how to share a pizza fairly long before they learn formal representations of fractions. Constructivist methods make extensive use of cooperative learning, projects, and integrated thematic units. They use many external representations of mathematical ideas, such as base-ten blocks, pictures, and stories. Constructivist theories see the learner as active, intrinsically motivated, and possessing background knowledge and experience that can and must be taken into account in instruction (Paris & Byrnes, 1989). In this view, the task of mathematics instruction is more to introduce students to symbolic representations of concepts they already possess than to teach completely new ideas. For example, children arrive in kindergarten knowing a great deal about combining and separating, more and less, halves and wholes, and so on. Constructivist teaching methods recognize and build on this knowledge, emphasizing discovery, reflection, multiple solutions, and explanation of learning processes by children themselves (Resnick, 1992).

The broad influence of standards developed by the National Council of Teachers of Mathematics, the acceptance of closely related standards by many states, and the development of performance assessments increasingly used for state accountability purposes, have all added significantly to the press for more constructivist teaching in elementary schools. The stakes for schools and students are rising. State-of-the-art state mathematics assessments require students to solve complex, non-routine problems and to explain their thinking processes.

These new standards and assessments create significant opportunities for reform in the teaching of mathematics at all levels. Yet they also create a serious danger. Studies of new performance assessments are finding that poor and minority students are scoring worse on these assessments (relative to middle-class students) than they do on traditional standardized measures (Shavelson, Baxter, & Pine, 1992). If anything, this problem is likely to become worse. Moving from traditional to constructivist teaching requires a substantial investment in top-quality professional development. Middle class school districts are likely to be able to make such investments and to be able to hire elementary teachers who are already reasonably proficient in mathematics. Impoverished schools are less likely to have teachers who are up-to-date in new conceptions of mathematics or to be

able to provide the months of inservice often required to enable even good teachers with strong interests and backgrounds in mathematics to internalize learner-centered teaching in mathematics.

A number of new approaches to mathematics curriculum and instruction have been developed for elementary schools to help them move toward constructivist conceptions of learning. Examples include Conceptually Based Instruction (Hiebert & Wearne, 1993), Cognitively Guided Instruction (Carpenter & Fennema, 1992), Supporting Ten-Structured Thinking (Fuson, 1992), and QUASAR (Stein & Lane, 1995). These and other methods are expanding in use in elementary schools. Yet there is still a need for further development and research directed at creating practical constructivist methods capable of being used on a large scale by all teachers, not only those with particular interests and backgrounds in mathematics. Many projects have shown success on a limited scale at introducing constructivist methods in elementary schools, including those serving many students placed at risk (see, for example, Fuson, 1992; Jamar, 1995; Stein & Lane, 1995; Campbell, Cheng, & Rowan, 1995; Carpenter Fennema, Peterson, Chiang, & Loef, 1989). However, mathematics instruction, especially in urban elementary classrooms, remains overwhelmingly algorithmic, teacher-centered, and traditional.

The goal of reform in elementary mathematics must be to provide deep understanding of mathematical ideas for *all* students, not just for those fortunate enough to have teachers with extraordinary skills and interests in mathematics. Mathematics for *all* will require approaches very different from those needed to demonstrate on a small scale that students can learn in new ways. It will require the development of new curricula and school support structures capable of ensuring that every elementary teacher, even those in high-poverty, underfunded schools, will be able to enable students to be strategic, flexible, self-aware, and motivated problem solvers in mathematics.

This report describes three evaluations of a mathematics instruction program designed to make constructivist mathematics instruction practical and successful for a broad range of children and teachers in high poverty schools. This program, called MathWings, is part of a comprehensive school reform approach called Roots and Wings (Slavin, Madden, & Wasik, 1996; Slavin & Madden, 2000), which was funded by New American Schools. Roots and Wings adds MathWings as well as social studies and science programs to a reading, writing, and language arts program called Success for All (Slavin, Madden, Dolan, & Wasik, 1996; Slavin & Madden, in press).

The development of MathWings drew heavily on the experience of developing Success for All, although the curricular approaches are quite different. Both strategies emphasize well-structured student materials, frequent assessment, cooperative learning, effective classroom management methods, and extensive teacher training and followup.

The idea is to improve the instructional strategies of all teachers, whether or not they are experts in mathematics, but to build in enough flexibility to allow the best teachers to go further.

This report describes MathWings and presents the first seven evaluations of the program's effects on student mathematics achievement in ten high-poverty schools.

MathWings: Program Description

MathWings is based on the standards of the National Council of Teachers of Mathematics. A program to prepare students for mathematics in the twenty-first century needs to actively involve students in the conceptual development and practical application of their mathematics skills. MathWings reflects a balance of solid mathematical conceptual development, problem solving in real world applications, and development of necessary mathematics skills.

Students enter school with a great deal of mathematical knowledge. They know about combining and separating, halves and wholes, and so on. What they need is a bridge between their pre-existing knowledge and the formal representation of this knowledge in mathematical symbols. This requires the use of manipulatives, demonstrations, and discovery to help students build mathematical understanding. MathWings uses cooperative learning at all age levels while incorporating problem solving in real situations, skill practice and reinforcement for efficiency in application, calculator use, alternative assessments, writing, connections to literature and other disciplines, and application to the students' world and personal experiences. Although students help each other learn, they are always individually accountable for their own learning, and are frequently assessed on their progress in understanding and using math (see Slavin, 1995).

Major Components

The *NCTM Principles and Standards for School Mathematics* (2000) advocate emphasizing problem solving rather than rote calculation with algorithms. MathWings lessons involve the students in problem solving in "real" situations to give validity and purpose to their mathematics explorations, and in daily problem solving as part of the routine of math class. MathWings lessons also make connections to literature, science, art, and other subjects as well as the students' world and personal experiences to provide this real world problem solving context.

Another strand of the Standards is mathematical reasoning. Students develop their ability to think through and solve mathematical problems when they use manipulatives to develop concepts and then represent what is actually happening with symbols. MathWings units are constructed to develop concepts from the concrete to the abstract so that each step of the reasoning is clarified. The Standards also promote the use of calculators for developing concepts and exploring advanced problem solving situations rather than checking answers or replacing skills and mental math. MathWings students use calculators in this way to increase both their mathematical reasoning skills and the scope and complexity of the problems they can solve, and to focus their energy on mathematical reasoning rather than mere mechanical calculation.

The Standards emphasize communication, both oral and written, to clarify, extend, and refine the students' knowledge. MathWings students constantly explain and defend their solutions orally throughout the lessons, and regularly write in their logbooks. This emphasis on communication extends to the assessments as well. The Standards suggest the use of alternative assessments, which incorporate communication as well as calculation. MathWings units involve the students in many different types of assessment. The students complete concept checks in which they explain their thinking as they solve problems after every few lessons. They work on performance tasks at the end of each unit to use the skills they have learned to solve practical real world situations and explain and communicate about their thinking. Teacher observations of students at work with manipulatives, collecting data, and other activities, as well as their written and oral communications, are all used to assess their understanding.

The newest strand of the Standards is representation. MathWings helps students progress from their first personal representations of mathematical ideas to the conventional representations so that they can learn and communicate mathematically. They learn to solve problems using manipulatives and represent their solutions with symbols. In MathWings concepts are developed by a progression of concrete, pictorial, and abstract representations and students are challenged to represent problems and solutions in many different ways. They use representations to organize and interpret data, to model situations, to clarify their thinking, and to facilitate communication.

The use of cooperative learning in MathWings is based on years of research regarding effective strategies for classroom instruction. This research has shown that the cognitive rehearsal opportunities presented by cooperative learning, as well as the opportunities for clarification and reteaching for students who do not catch a concept immediately, have positive effects on academic achievement. Research has also shown that using cooperative learning in the classroom can have positive effects on inter-ethnic relationships, acceptance of mainstreamed, academically handicapped students, student

self-esteem, liking of others, and attitudes toward school and teachers (Slavin, 1995). In cooperative learning, students work together to learn; the team's work is not done until all team members have learned the material being studied. This positive interdependence is an essential feature of cooperative learning.

Research has identified three key components which make cooperative learning strategies effective: team recognition, individual accountability, and equal opportunities for success. In MathWings, as in other Student Team Learning strategies (Slavin, 1994), students work in four-member, mixed-ability teams. Teams may earn certificates and additional means of recognition if they achieve at or above a designated standard. All teams can succeed because they are working to reach a common standard rather than competing against one another. The team's success depends on the individual learning of all team members; students must make sure that everyone on the team has learned, since each team member must demonstrate his or her knowledge on an individual assessment. Students have an equal opportunity for success in MathWings because they contribute points to their teams by improving over their own individual performance, by bringing in their homework, and by meeting particular behavior goals set by the teacher. Students who are typically seen as low achievers can contribute as many points to the team as high achievers.

The MathWings program is designed to use the calculator as a tool, not a crutch. Calculators enable the students to explore and demonstrate concepts in an appealing way. Students discover that they need to check their calculator answers for accuracy since the calculator is only as accurate as the information and process that is keyed into it. Thus, students develop their skills in estimating and predicting outcomes. Students also spend more time actually thinking about math and the processes that will most efficiently solve a given problem, rather than focusing completely on tedious and lengthy calculations. Because of the speed of calculation with calculators, students are more willing to try several approaches to solving a problem situation or to reevaluate their answers and try a different method of solution. Finally, calculators build students' confidence in mathematics as they receive much positive reinforcement from correct solutions. This leads, in turn, to a greater willingness to tackle more challenging mathematical situations in the belief that they have the ability and the tools to solve them.

Manipulative use is a basic building block of the MathWings program at all levels. Students construct understanding and develop original methods for solving problems using manipulatives. As they work with manipulatives and discuss and defend their thinking, they gradually make the concepts their own. Once a problem can be solved with manipulatives, students draw a picture and then write a number sentence to represent what was happening with the manipulatives as they solved the problem. This gradual

progression from concrete to pictorial to abstract representation provides a solid foundation of understanding upon which the students can build. Every method or algorithm can be understood, and even reinvented, with manipulatives, thus replacing rote learning of algorithms with understanding of concepts and ways to efficiently apply them. Once the concepts have been firmly established and students understand how the algorithms work, they move away from using concrete manipulatives. However, manipulatives can be revisited at any time to remediate or extend a concept as needed.

Most MathWings whole-class units have a literature connection which is an integral part of the concept development. Literature provides a wonderful vehicle for exploring mathematical concepts in meaningful contexts demonstrating that mathematics are an integral part of human experience. The use of literature incorporates the affective elements and demonstrates the aesthetic aspect of mathematics. Finally, the use of literature encourages students to pose problems from real and imaginary situations and to use language to communicate about mathematics.

MathWings involves the students in daily routines that frame each lesson and are efficient ways to provide for team management, problem solving, and skill practice and reinforcement to facilitate efficiency in calculation and application. Once the students have mastered the facts and basic algorithms, they become tools for the students to use as they develop concepts and problem solving. These routines include facts practice at both levels. In Intermediate MathWings there are weekly timed facts tests to encourage mastery of the basic facts, and then practice problems at varying difficulty levels to provide for fluency in the use of the essential algorithms. There are also daily real world applications in Primary MathWings and daily problem solving in Intermediate.

MathWings has two major forms. Primary MathWings is used in grades 1-2; Intermediate MathWings in grades 3-5. The MathWings program is quite similar at the two levels, with one key exception. In Primary MathWings, the main element of daily lessons, called Action Math, is taught every day to the entire class and an additional interactive bulletin board activity called 15 Minute Math is included daily. Intermediate MathWings also uses Action Math, but intersperses Action Math Units with Power Math, which provides individualized work to help students gain facility and confidence in algorithms, remediate gaps in prior skills and concepts, master grade-level material, or accelerate their mathematics skill development. Otherwise, Primary and Intermediate MathWings use similar routines, procedures, and teaching methods, as appropriate to children's age levels.

Primary MathWings.

In Primary MathWings, students spend 75 minutes in math daily. There are two start up routines: 15 Minute Math and Check-In. 15 Minute Math can be done at the beginning of the lesson or at any other time during the school day. It uses an interactive bulletin board that contains activities based on everyday mathematical experiences. Students use a calendar, look at patterns, create a weather graph, keep a tally to show the number of days they have been in school, and do many other "thinking tasks." The activities are revisited repeatedly to provide opportunities for developing fluency with basic math skills. During 15 Minute Math, students also practice their basic facts during a daily 3-minute facts practice session. With a facts partner, students work on a weekly facts game or activity. There is a menu of different games and activities for facts practice.

The lesson begins with Check-In, which lasts approximately 5 minutes. The teacher quickly collects the Home Connection from the night before and assigns partners for the day. A Review to Remember activity gives students a chance to practice their basic facts and other skills that were introduced earlier in the year. Skills and concepts are reviewed and spiraled throughout the school year. Flashback follows the Review to Remember activity and is a time for students to recall mathematics concepts and activities from the previous lesson to build on in the new lesson.

The Primary MathWings lesson is made up of Active Instruction, Teamwork, and Direct Instruction. Active Instruction provides a springboard for new ideas, concepts, terminology, etc. It is the part of the lesson that invites students to draw from their background knowledge while discussing new ideas and concepts. This part of the lesson might contain a new literature piece or poem, the teacher might introduce a new problem situation, or the students might brainstorm ideas, create a web, make a list, make observations about something, predict outcomes, or estimate.

Teamwork is intended to provide students with an opportunity to test their ideas, practice what they have discussed in Active Instruction, generate and organize data, and communicate about mathematics. Students in first grade most often work in pairs, especially in the earlier parts of the year. Students in second grade work in pairs or teams, with a greater emphasis on teamwork during the second half of the year. Teachers begin the Teamwork phase of the lesson by clearly explaining and modeling the team or paired activity. In most lessons, students work with manipulatives. Prior to using these manipulatives, students are given approximately 2 minutes to explore. Students then work with a partner or with their team to complete the mathematics activity while the teacher circulates to assist and informally assess them. During Teamwork, students may complete handouts, collect and record data, draw illustrations, or write about the activity.

Direct Instruction is the part of the lesson where the whole class shares the results of Teamwork, analyzes data, and discusses what they have learned. This is also a time for

the teacher to clarify confusions, review any terms that have been introduced, and ask specific questions to ensure that the mathematics concepts involved in the lesson activities become clear to students. Sometimes students write in their Mathematics Log during this part of the lesson.

The closure routines are included in Reflection. During Reflection students discuss what they have just done. They share what they liked about the lesson, what they have learned, and where they are confused. Then the teacher summarizes the key concepts, reviews vocabulary, and explains the Home Connection assignment. Reflection ends with Team Wrap-Up to have the students get ready for the next class.

Intermediate MathWings.

In Intermediate Mathwings students spend at least 60 minutes daily in their mathematics class, although 75 minutes is recommended. Daily lessons consist of three components: Check-In, Action Math or Power Math, and Reflection.

The first 15-minute segment is Check-In, an efficient class start-up routine in which the teams regularly complete one challenging real world problem and then discuss their various strategies together. They also complete a facts or fluency study process twice a week, and check homework briefly every day.

The next 40 - 55 minutes in either Action Math or Power Math is the heart of the lesson. When the class is doing an Action Math unit, the lesson involves the students in active instruction, teamwork, and assessment. During active instruction the teacher and students interact to explore a concept and its practical applications and skills. The teacher may present a challenging problem for students to explore with manipulatives to construct a solution, may challenge the teams to use prior knowledge to discover a solution, and may ask the teams to find a pattern to develop a rule.

During teamwork the students come to consensus about their solutions to problems, their understanding of concepts, and their thinking. A team member is chosen randomly to share his or her ideas with the class. Then students individually practice similar problems with teammates available for support. The team members check answers with each other and rehearse to be sure that every team member can explain them.

At the end of the teamwork, there is a brief feedback opportunity. The teacher randomly chooses a team member to share the ideas or solutions of the team, and to explain their thinking. This enables the teacher to assess the understanding of the group as a whole and insures that teammates are invested in making sure that all members of the team are mastering the concepts.

The final portion of an Action Math lesson is assessment. One or more brief problems are used as a quick individual assessment of mastery of the concept or skill explored in the lesson.

Intermediate classes intersperse one- to two-week Power Math units among Action Math units. During these units, the 40 - 55 minute heart of the lesson involves each student in remediating, refining, or accelerating his or her skills. This component is an adaptation of Team Accelerated Instruction, an individualized math program found to be effective in several studies (Slavin, Leavey, & Madden, 1984). Power Math covers a range of skills from basic addition to statistics and algebra. Students work at their own pace on the skill which they need to practice, completing check outs and mastery tests successfully to move to another skill they need to practice. Teammates check each other's work and provide help as needed. Students who have mastered the basic skills explore accelerated units at their own pace. The teacher teaches mini-lessons to small groups of students (working on the same skills) gathered from various teams while the other students continue to work individually.

The last five-minute segment of class is Reflection. This is an efficient routine to bring closure to the class time. During Action Math units, reflection involves a quick summary of the key concepts by the teacher. During both Action Math units and Power Math units, homework sheets are passed out, and a short entry is written in the MathWings Logbook in response to a writing prompt about the lesson.

All students should not only be given the opportunity to establish a solid foundation in mathematics, but also the opportunity to extend and stretch their knowledge and experience in mathematics. Thus, a program of mathematics should include a structure to accommodate a diversity of abilities and prior mathematical knowledge, while ensuring that all students experience the depth, breadth, and beauty of mathematics. The MathWings curriculum incorporates this philosophy in its development.

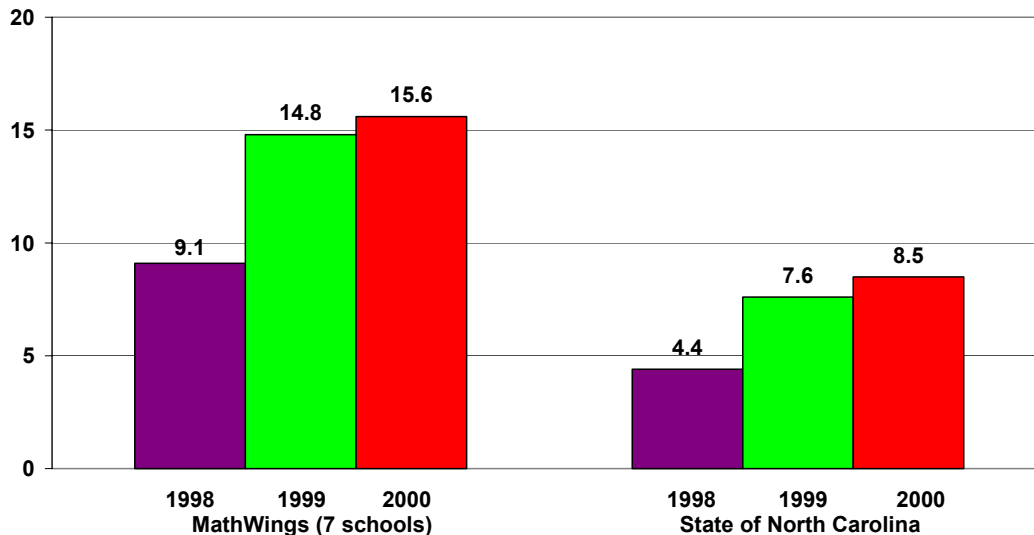
Research on MathWings

Data on the achievement outcomes of MathWings were obtained from every MathWings school in the U.S. that began the program in 1998 or earlier and had consistent math achievement data available on the Internet. Such data were available for four early pilots in rural Maryland, seven schools in North Carolina, six in California, and one each in San Antonio, Texas, and Page, Arizona. In all of these schools, gains in MathWings schools were compared to those for the state as a whole on the same measures, state accountability scales for mathematics.

State of North Carolina

The largest evaluation of MathWings was a study of all seven MathWings schools in the State of North Carolina. These schools began to implement MathWings in 1997. North Carolina makes End-of-Grade achievement data for all of its schools available on the Internet, and these data were used to carry out an evaluation of test score gains in Success for All. Table 1 summarizes demographic data on the schools, all of which were in impoverished rural areas (Anson County is the most impoverished county in North Carolina). Overall, 60% of the MathWings students qualified for free lunch. 53% of the students were African-American, 37% white, and a significant number in three of the schools were American Indians. Figure 1 shows that over a three-year implementation period, MathWings schools gained 15.6 percentage points in students at grade level on the End-of-Grade test. In the state as a whole, gains were only 8.5%.

Figure 1
North Carolina MathWings Schools vs. State Gains
Cumulative Gains from 1997 in Percent at Grade Level
End of Grade Test -- Mathematics, Grades 3-5



<u>School</u>	<u>District</u>	<u>No. Students</u>	<u>% Free Lunch</u>	<u>Percent</u>				
				<u>W</u>	<u>AA</u>	<u>H</u>	<u>Asian</u>	<u>Am. Ind.</u>
Ansonville	Anson Co. PS	233	53	46	53	0	1	0
Morven	Anson Co. PS	434	72	4	96	0	0	0
Central	Anson Co. PS	627	70	22	77	0	1	0
Star-Brisco	Montgomery Co. PS	461	46	62	18	18	1	0
Laurel Hill	Scotland Co.	622	50	62	20	0	0	18
Pate-Gardner	Scotland Co.	292	68	40	51	0	0	9
Wagram	Scotland Co.	570	64	24	58	0	0	18
Mean		463	60	37	53	3	0	6
State Mean			38	62	31	4	2	1

Source: Common Core of Data
Key: W=White; AA = African-American; H = Hispanic; Am. Ind. = American Indian

State of California

The second state to have enough schools for state-level analysis was California, where six schools began MathWings in 1998. Table 2 presents demographic data on these schools, which were in Sacramento and in rural areas of Northern California. Overall, 75% of the students qualified for free lunch (compared to 47% in the state as a whole); 65% were white, 7% African American, 15% Hispanic, 8% Asian American, and 5% American Indian.

Figure 2 summarizes gains on the Stanford 9 mathematics scale. MathWings students gained 22.2 scale score points from 1998-2000, while other California schools gained only 12.7 points.

Figure 2
California MathWings Schools vs. State Gains
Cumulative Gains from 1998 in Scale Scores
Stanford-9 -- Mathematics, Grades 2-5

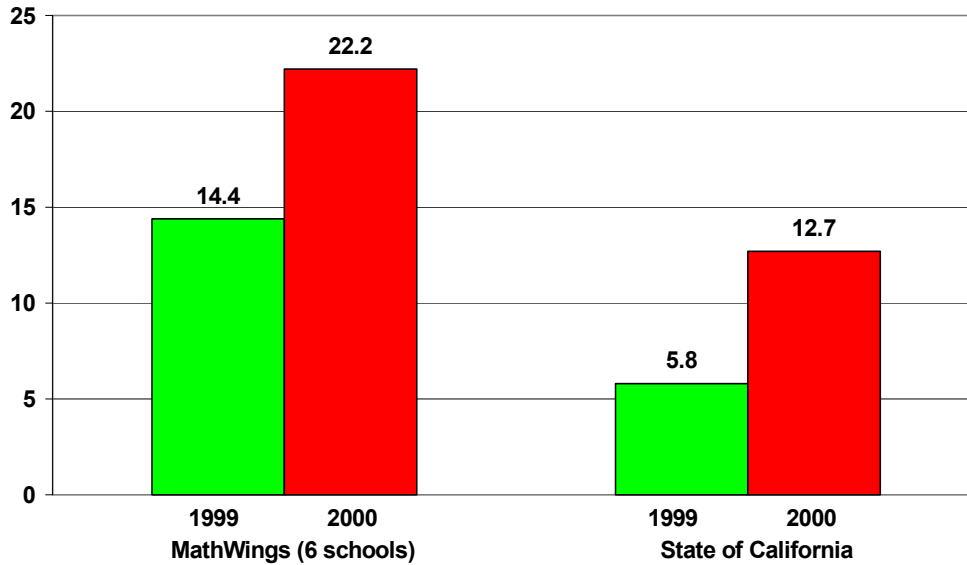


Table 2
Demographic Information
California MathWings Schools

<u>School</u>	<u>District</u>	<u>No. Students</u>	<u>% Free Lunch</u>	<u>Percent</u>				
				<u>W</u>	<u>AA</u>	<u>H</u>	<u>Asian</u>	<u>Am. Ind.</u>
East Lake	Konocti USD	202	79	76	8	6	1	8
Lower Lake	Konocti USD	496	68	75	5	8	3	8
Pomo	Konocti USD	569	77	72	9	13	1	5
Burns Valley	Konocti USD	320	90	67	5	19	2	6
Woodbine	Sacramento City USD	350	95	13	15	34	38	0
McCloud	McCloud Union	175	43	84	2	11	2	1
Mean		352	75	65	7	15	8	5
State Mean			47	36	8	43	8	1

Source: Common Core of Data

Key: W=White; AA = African-American; H = Hispanic; Am. Ind. = American Indian

St. Mary's County, Maryland

The pilot schools for all of Roots & Wings, including MathWings, were four schools in and around Lexington Park, a rural community in Southern Maryland. The four schools are by far the most impoverished schools in the district; on average, 48% of their students qualify for free lunch. The schools began implementing the reading aspects of Roots & Wings in 1993-94, and then began to phase in MathWings in grades 3-5 in 1994-95. By 1995-96, all teachers in grades 3-5 were using MathWings, and piloting in grades 1-2 began in 1996-97.

Because there were no schools in St. Mary's County comparable in poverty or prior achievement to the Roots & Wings schools, an experimental-control comparison within the district could not be carried out. Instead, test score gains over time in the Roots & Wings schools were compared to those in the state as a whole. The test is the Maryland School Performance Assessment Program, or MSPAP, a state-of-the-art performance assessment in which students are asked to solve complex problems, set up experiments, write in several genres, and so on. The MSPAP uses matrix sampling, which means that different children take different parts of a broad, comprehensive test. Scores are reported in terms of percentages of children achieving at high levels labeled "satisfactory" and "excellent" in each school. In elementary schools, only third and fifth graders are assessed.

The results for the MSPAP mathematics scales are summarized in Figures 3 and 4. Figure 3 shows that third graders in the four MathWings pilot schools started off far below the state average. By 1995, they had essentially caught up to the state average and, in 1996, exceeded it. In 1997, the scores slipped slightly behind those of the state, but were still substantially ahead of baseline, both in absolute terms and relative to state means. Exactly the same pattern was found in fifth grade, where, by 1996, the MathWings pilot schools also had higher scores than the state average, and fell slightly below in 1997.

Figure 3
Mathematics Performance, Maryland School Performance Assessment Program, 1993-97
MathWings Pilot Schools vs. State of Maryland
Grade 3

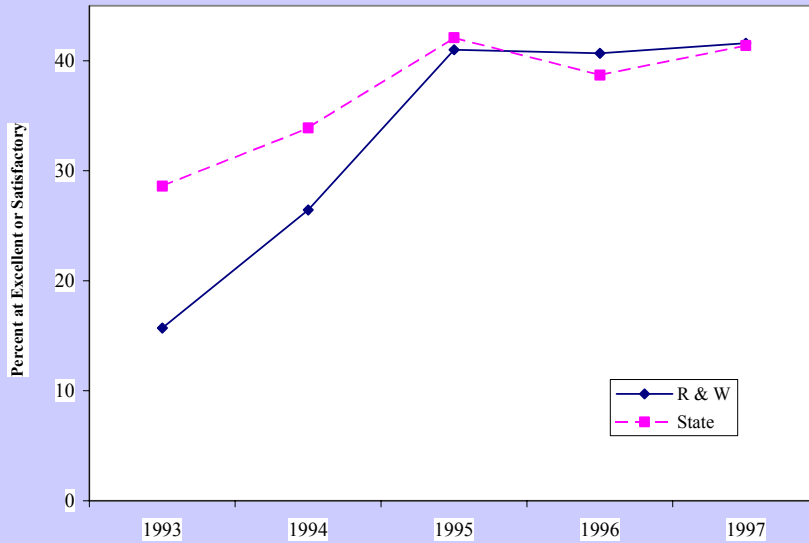
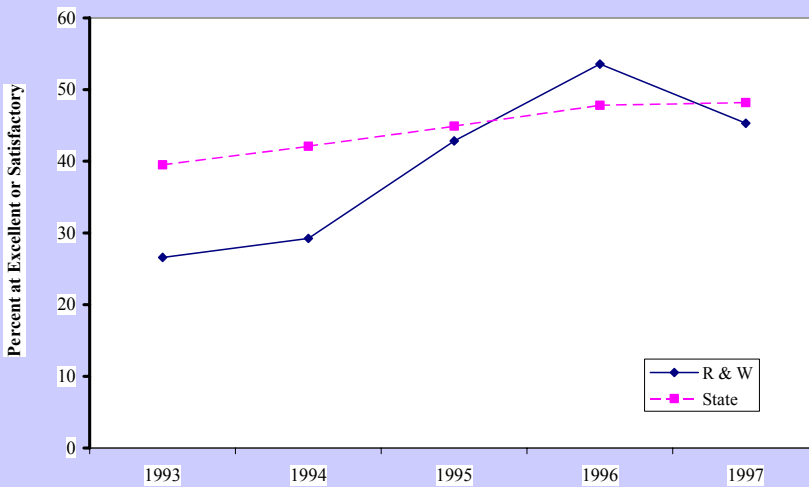


Figure 4
Mathematics Performance, Maryland School Performance Assessment Program, 1993-97
Math Wings Pilot Schools vs. State of Maryland
Grade 5



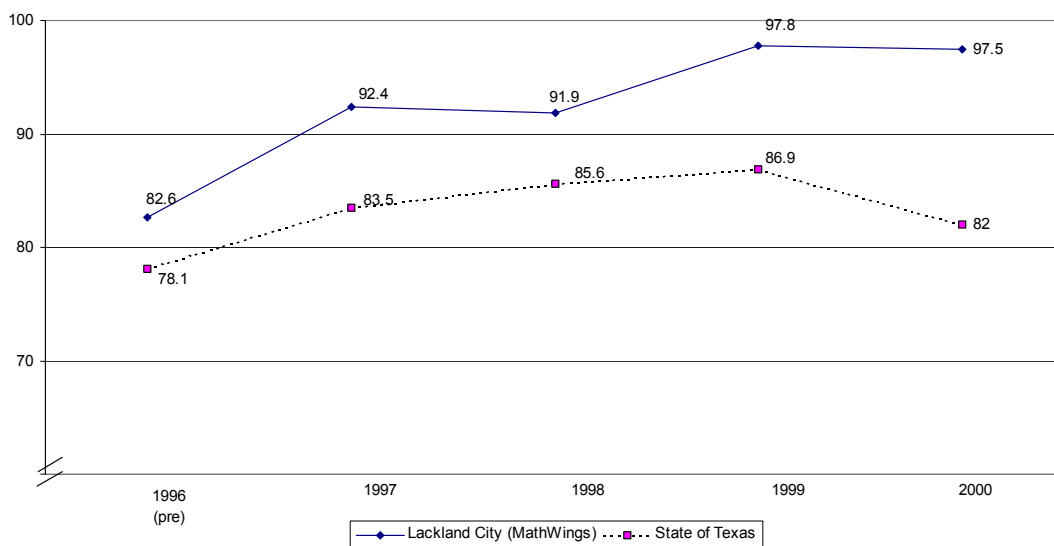
San Antonio, Texas

One of the first schools using MathWings outside of Maryland was Lackland City Elementary School in the Northside Independent School District in San Antonio, Texas. Lackland City had implemented the Success for All reading program in 1994-95, and then began to pilot MathWings in 1996. Lackland City is one of the most impoverished schools in its district; 86% of its students qualify for free lunch. A majority of its students are Latino (78%), with a high proportion categorized as limited English proficient.

Students in Texas are tested annually on the Texas Assessment of Academic Skills, or TAAS. Scores are reported in terms of the percentages of children passing the TAAS in each subject. Figure 5 shows the TAAS mathematics gains for Lackland City in grades 3, 4, and 5 from 1996 (just before the program began) to 2000.

As Figure 5 illustrates, students in all three grades made substantial gains on the TAAS, in comparison to other Texas students. In fact, in 1999 and 2000 virtually all students at Lackland City passed the TAAS-Math. Although Lackland City is far more impoverished than its district average (86% free lunch vs. 42% for the district), and the state average (45%), the school's math scores started near those of the state as a whole and are now 15.5 percentage points ahead of the state mean.

Figure 5
Lackland City (TX) Elementary vs. State Gains
Percent Passing, 1996 (Pre) - 2000
TAAS - Mathematics, Grades 3-5

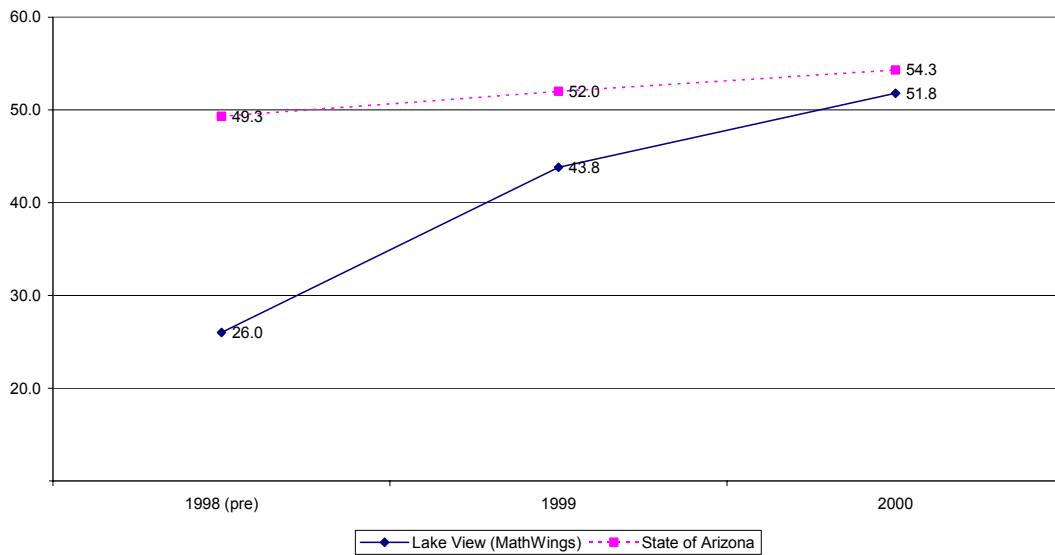


Page, Arizona

Lake View Elementary School, in rural Northern Arizona, serves a student population that is approximately two-thirds Navajo and one-third white. Approximately 54% of the students qualify for free or reduced-price lunch. Lake View began implementation of Success for All in 1996, and added MathWings in 1998.

Figure 6 shows the progress of Lake View students on the Stanford 9 mathematics scale. Substantial increases from pre- to post-test were seen at all grade levels tested, 3-5. These gains were much greater for Lake View than for Arizona as a whole. Students at Lake View began performing 23.3 percentage points below the state mean at pretest, but were only 2.5 points behind the state in 2000.

Figure 6
Lake View (AZ) Elementary vs. State Gains
Percentile Ranks, 1998 (pre) - 2000
Stanford-9 - Mathematics, Grades 2-5



Survey

A 2000 national survey of 58 MathWings schools found that principals and facilitators in these schools consistently believed that their children were benefitting from MathWings. With respect to computations, 45% of respondents thought children were benefitting “a great deal,” and another 47% thought they benefitted “somewhat.” One respondent (2%) did not see a benefit, and four (7%) didn’t know yet (because they were first year schools). In concepts, 59% thought children benefitted a great deal, 28% “somewhat,” and 14% didn’t know yet.

Conclusion

Trends on state accountability measures for seven schools across the state of North Carolina, six schools in California, and six additional schools in Maryland, Texas, and Arizona show substantial gains due to implementation of MathWings. In all cases, high-poverty schools initially performing significantly below district or state averages moved much closer to those averages after implementing MathWings, sometimes reaching or exceeding state means. The schools assessed are not a selected group, but include every school that implemented MathWings starting in 1998 or earlier in states with consistent and accessible test score data over the period from program inception to the present.

There is much more to be done in the evaluation of MathWings. It is possible that at least part of the gains in mathematics performance is due to implementation of the Success for All reading program, implemented in all of these MathWings pilot schools 1-3 years earlier. However, the dramatic gains seen in these 19 schools are unlikely to have been entirely due to the reading program or to other factors; in all districts assessed, baseline scores reported here would already reflect the reading implementations, and the largest gains were seen in the years when MathWings was implemented.

These results demonstrate that schools serving many children in poverty can substantially accelerate the mathematics achievement of their students using an approach tied to NCTM standards but developed to be practical for a broad range of teachers and effective for a broad range of students.

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