

## **The Impact of Research-Based Mathematics Instruction on Students With Disabilities**

**The North Carolina State Improvement Project  
North Carolina Department of Public Instruction  
2008-2009**

### **Introduction**

The North Carolina State Improvement Project (NCSIP), funded by the Office of Special Education Programs (OSEP) program in the U.S. Department of Education provides research-based instruction for students with disabilities in the North Carolina Public Schools. The purpose of this report is to present the mathematics progress of students with disabilities receiving mathematics instruction from teachers who have had extensive and intensive training in the delivery of research-based mathematics instruction.

Other purposes of this report are to (1) present the types of data collected, (2) how these data are collected and used to evaluate the effectiveness of the specialized mathematics instruction and, (3) how these data can be used to improve the mathematics skills of students with disabilities.

### **Research-Based Mathematics Instruction For Students With Disabilities**

Until recently there has been little national research review to help practicing educators select and implement effective mathematics instructional methods and procedures. To this end the U.S. Department of Education established a National Mathematics Advisory Panel in 2006 to review the best available scientific evidence and to recommend how to improve the mathematics performance of students with disabilities who are having significant difficulties making progress in mathematics.

The Panel's final report was released in the spring of 2008 and a large section of the report focused on identifying and implementing effective mathematics instruction for students with disabilities and other students who are not up to grade level. The Panel's review indicates that explicit methods of instruction are effective with students with learning disabilities and other students struggling with mathematics. Below is an excerpt from the Panel report.

“Explicit systematic instruction was found to improve the performance of students with learning disabilities in computation, solving word problems, and solving problems that require the application of mathematics to novel situations. Explicit systematic instruction typically entails teachers explaining and demonstrating specific strategies and allowing students many opportunities to ask and answer questions and to think aloud about the decisions they make while solving problems. It also entails careful sequencing of problems by the teacher or through instructional materials to highlight critical features.

Significant positive effects were also found for Direct Instruction (a specific type of explicit instruction that provides teachers with scripts and that calls for frequent

interactions between students and teachers, clear feedback to students on the accuracy of their work, and sequencing of problems so that critical differences are highlighted). Other forms of explicit systematic instruction have been developed with applications for students with learning disabilities. These developments reflect the infusion of research findings from cognitive psychology, with particular emphasis on automaticity and enhanced problem representation.” (Final Report, National Mathematics Advisory Panel, 2008)

The panel reviewed a small number of studies on the use of visual representations that were non-significant in terms of improving math performance. The panel also found that when mathematics instruction employed visual representations together with explicit instruction usually a significant positive effect was found.

The Panel also recommended;

“... that students with learning disabilities and other students with learning problems receive, on a regular basis, some explicit systematic instruction that includes opportunities for students to ask and answer questions and think aloud about the questions and think aloud about the decisions they make while solving problems. This kind of instruction should not comprise all the mathematics instruction these students receive. However, it does seem essential for building proficiency in both computation and the translation of word problems into appropriate mathematical equations and solutions. Some of this time should be dedicated to ensuring that students possess the foundational skills and conceptual knowledge necessary for understanding the mathematics they are learning at their grade level.” (Final Report, National Mathematics Advisory Panel, 2008)

### **Data Collection and Analysis Procedures**

The assessment procedures developed and implemented by the Accountability Services Division in the North Carolina Department of Public Instruction are used by the NCSIP project to measure student progress in reading. End-Of-Grade mathematics assessments are annually administered to all students statewide in the spring of each year. These assessment results are used by NCSIP to compare the annual mathematics skills progress of three specific groups of students; students receiving NCSIP research-based instruction, students with disabilities statewide, and all public school students in North Carolina.

Nine of the NCSIP research-based mathematics instruction sites located in local education systems submitted mathematics data to be included in this evaluation process. However, two of these projects submitted data for only ten students which is too small to be included in the analyses.

An Evaluation Coordinator in each of the LEAs completed the data collection forms using the data generated by statewide annual assessments. The NCSIP data collection forms can be found at <<http://www.ncsip.org>> in the Evaluation and Accountability section under *Evaluation Resources*.

The NCSIP evaluation process is designed to measure the extent to which the project's goals and objectives have been achieved. The goal of the NCSIP project is to improve basic skills performance (reading/writing and mathematics) of students with disabilities.

The evaluation process compares the increase of the percentage of NCSIP students with disabilities performing at or above grade level in mathematics with students with disabilities statewide as well as all non-disabled students statewide performing at or above grade level. These comparisons are made using the 3<sup>rd</sup> grade through 8<sup>th</sup> grade composite mathematics performance of students. The data analyses were conducted using the SAS JMP program.

### **Limitations of the NCSIP Evaluation Process**

The NCSIP evaluation system does not employ a controlled research design. Students are not randomly assigned to specific instructional treatment groups nor does the project control for a number of differences in the groups of students being compared. For example, many students with disabilities participating in the statewide assessment conducted by the Department of Public Instruction do not demonstrate below grade level mathematics skills. Students receiving mathematics instruction in NCSIP projects participate in the research-based instruction because they are seriously below grade level in mathematics skills. Also, the evaluation process assumes that each of the LEA mathematics site participating in the evaluation process accurately transfers the student progress data to the NCSIP data collection forms accurately.

In this report two types of data analyses will be presented and briefly discussed. These include (1) data demonstrating the extent to which the project goals for improving basic mathematics skills performance for students with disabilities has been met and (2) data for making decisions to improve the effectiveness of the mathematics instruction interventions employed by the NCSIP project.

### **1. Evidence Supporting Progress In The Improvement Of Mathematics Skills Of Students With Disabilities**

The NCSIP project uses the End-Of-Grade data collected by the Accountability Services Division in the North Carolina Department of Public Instruction to measure student progress in the various content areas. To measure annual gains the current year's percentage of students at or above grade level (%AAGL) in mathematics are compared to the previous year's percentage of students demonstrating mathematics skills at or above grade level.

Four different assessment procedures are used to measure the percentage of students with disabilities performing at or above grade level (%AAGL). These assessment categories included (1) Multiple Choice, (2) North Carolina Checklist of Academic Standards (NCCLAS), (3) NCEXTEND2, and (4) NC EXTEND1. The primary purpose for including four different assessment procedures is to assure that students with disabilities will have ample opportunities to demonstrate their knowledge within the framework of the curriculum.

Results

In this report two types of data analysis will be presented and briefly discussed. These include (1) data demonstrating the extent to which the project goals for improving mathematics skills have been met and, (2) data that can be used for making decisions to improve the effectiveness of the mathematics instruction employed by the NCSIP project.

**1. Evidence Supporting Progress In The Improvement Of Mathematics Skills Of Students With Disabilities**

Table 1 below compares the progress of students with disabilities receiving mathematics instruction in the NCSIP project with the progress made by all students with disabilities and all non-disabled students in the North Carolina schools during the 2008-2009 school year. Ninety-six percent of the NCSIP students were assessed using the Multiple Choice or the NCEXTEND2 assessment.

Table 1  
 Comparison of Performance in Mathematics Of NCSIP Students  
 Receiving Research-Based Mathematics Instruction ,  
 All Students with Disabilities in North Carolina, and  
 All Non-Disabled Students In North Carolina  
 2008 – 2009

Students Assessed	N	%AAGL 2008*	%AAGL 2009*	% Points Gained
NCSIP Students	277**	23	41	18
All NC Students With Disabilities	08-85838 09-86039	43	55	12
All NC Non-Disabled Students	08-579221 09-586689	74	84	10

\* Percent of Students Performing At or Above Grade Level

\*\* Number of Matched NCSIP Students for 2008 and 2009

As can be seen in Table 1 the percentage points gained by NCSIP students (18) is six percentage points higher than the percentage points gained (12) by all students with disabilities state wide and eight percentage points higher than the gain made (10) by all non-disabled students in North Carolina.

It should be noted that NCSIP students with disabilities start at a lower percentage of students at or above grade level and then lower the gap by the end of the year. Also a case may be made that the NCSIP project is having a positive impact on lowering the gap between students with disabilities and all non-disabled students in North Carolina

**Analysis of Student Gains Across LEA Instructional Sites**

The NCSIP project has established **forty-three** research-based mathematics instruction sites located in school districts across North Carolina. A number of these sites are in a developmental stage and did not submit student progress data. Nine of the fully operational projects submitted student progress and demographic data for 2008-2009.

Table 2 presents the percentage of students receiving research-based instruction that are performing at or above grade level (%AAGL) in 2008-2009 and the percentage points gained or loss from 2008 to 2009.

Table 2  
Student Gains In Mathematics Abilities  
Across Local NCSIP Projects  
2008-2009

LEA Projects	ID Code	N	%AAGL 08	%AAGL 09	Gain
Buncombe	110	62	16	32	16
Cabarrus	130	44	18	27	9
Chatham	190	4*	--	--	--
Haywood	440	6*	--	--	--
Johnston	510	61	31	43	12
McDowell	590	11	18	27	9
Rutherford	810	22	46	67	21
Swain	870	17	29	59	30
Wake	920	50	16	36	20

\*Number of students too low to include in the data analyses

As can be seen in Table 2, in all of the NCSIP mathematics instruction sites submitting data there was a substantial gain in the percentage of students performing at or above grade level with an average gain of 17 percentage points. In two of the projects submitting data the number of students was too low to include these projects in the analyses.

There is a range of gains in the percentage of students performing at or above grade level from nine percentage points gained to 30 percentage points gained. The average gain of 17 percentage points compares favorably with the 12 percentage points gain average for all students with disabilities in North Carolina as shown in Table 1.

### Mathematics Skills Gains Across Student and Instructional Demographic Variables

Below Tables 3 through 13 present the reading gains of NCSIP students across several important demographic variables that may impact on student gains. The student variables addressed include type of disability, gender and ethnicity. Instructional variables addressed include grade level, instructional model, instructional group size, and instructional setting.

### Type of Disability and Mathematics Progress

Table 3 below presents data from the 2008-2009 school year across four disability areas of students plus a category of “Other” to include all other disability areas receiving research-based instruction. As can be seen there was a range of gains from twenty percentage points for the categories of SLD (Specific Learning Disabilities) and OHI (Other Health Impaired) to an eleven percentage point gain for BED (Behavior and Emotional Disorders) and EMD (Educational Mentally Deficient) students. However, for the category of Other (Disabilities) there was a two percentage point loss. Data are not available identifying the disabilities in the category of “Other.”

Table 3  
NCSIP Student Gains in Mathematics By Disability  
2008-2009

Disability	N	% AAGL* 09	% AAGL* 08	Gain
BED	9	22	33	11
EMD	51	20	31	11
SLD	120	22	44	<b>22</b>
OHI	71	18	38	20
Other	21	57	55	-2

\* Percent of students at or above grade level

\* No disability data available for 10 students

### Gender and Mathematics Progress

Table 4 below presents the mathematics progress of female and male students receiving NCSIP instruction during the 2008 school year. As can be seen 23% of Female students performed at or above grade level (%AAGL) in 2008 and 23% of the Male students performed at or above grade level in 2008. In 2009 38% of Females performed at or above grade level while 44% of the Males performed at or above grade level. Accordingly, Females showed a gain of 15 percentage points while males showed a gain of 21 percentage points.

Again, these gains compare very favorably to the percentage points gained by all Students With Disabilities across North Carolina (12%) and the percentage points gained by all Non-Disabled students (10) across North Carolina.

Table 4  
Gains in Mathematics By Gender  
2008-2008

Gender	N	% AAGL* 2008	% AAGL* 2009	Gain
Female	116	23	38	15
Male	163	23	44	21

\* % At or Above Grade Level

### Ethnicity and Mathematics Progress

As shown in Table 5 below gains were made by all three ethnic groups included in the analysis. The greatest gain (32 percentage points) was made by Hispanic students and the lowest gain (14 percentage points) was made by African-American students. Hispanic students gained 32 percentage points. The number of students in other groups was too low to include in the ethnicity analysis.

Table 5  
NCSIP Mathematics Gains By Ethnicity  
2008-2009

Ethnicity*	N	% AAGL* 2008	% AAGL* 2009	Gain
African-American	72	15	29	14
Hispanic	36	14	46	32
White	152	29	45	16

\* The total numbers for the categories of American Indian, Asian, Multi-Racial, and Other were too low to include in this analysis.

### Grade Level and Mathematics Progress

Gains by grade level are presented in Table 6 below.

Table 6  
Gains in Mathematics By Grade Level  
2008-2009

Grade Level	N	% AAGL* 2008	% AAGL* 2009	Gain
3 <sup>rd</sup> Grade	44	7	27	20
4 <sup>th</sup> Grade	42	26	48	22
5 <sup>th</sup> Grade	51	45	47	2
6 <sup>th</sup> Grade	58	19	45	26
7 <sup>th</sup> Grade	52	17	35	18
8 <sup>th</sup> Grade	30	23	47	24

\* % At or Above Grade Level

The smallest gain was made at the 5<sup>th</sup> grade level with a gain of only two percentage points. The largest gain of the percentage of students at or above grade level was twenty-six. The average gain across all six grades is approximately eighteen percentage points. These gains can be compared favorably with the gains made by all students with disabilities in North Carolina in 2008-2009.

## Instructional Model Used and Progress in Mathematics

Table 7 presents the gains made by students receiving mathematics instruction in one of three different model instructional protocols. These models included Numbers World published by Science Research Associates, Transitional Math published by Sopris-West, and a Wake County model instructional protocol used by the NCSIP instructional site in Wake County. The Wake County instruction protocol has been developed by NCSIP staff, consultants, and mathematics instructional staff.

These three instructional programs are considered to be effective research-based mathematics instruction models for struggling students, particularly high-incidence students with disabilities. Each of these instructional models is briefly discussed below. As can be seen in Table 7 students receiving the Numbers World instruction demonstrated a fifteen percentage point gain in the percentage of students at or above grade level during the 2008-2009 school year. Students receiving Transitional Math instruction gained twenty percentage points. The “Other” instructional model referred to is the Wake County School Remedial Warm-ups/Focus Lesson Model. Wake County students receiving the Wake County instruction gained nineteen percentage points for students at or above grade level from 2008 through 2009.

Table 7  
Gains in Mathematics By Instructional Model  
2008-2009

Instruction Model	N	% AAGL* 2008	% AAGL* 2009	Gain
Numbers World	111	21	36	15
Transitional Math	102	21	41	20
Other	62	29	48	19

\* % At or Above Grade Level

As can be seen above data were available for 202 students. Forty-four students received instruction using the Numbers World model curriculum, 124 students received instruction using the Transitional Math instruction model, and sixty-two students participated in an “Other” instructional program. Each of these model programs are briefly described below.

### Numbers World

The authors of the Numbers World mathematics instructional program published by Science Research Associates (SRA) are Sharon Griffin, Professor of Education and Psychology at Clark University, Douglas H. Clements, Associate Dean for Educational Technology and Professor of Learning and Instruction at University at Buffalo, and Julie Sarama an Associate Professor of Learning and Instruction at University at Buffalo.

Contributing Authors of Number Worlds include Kim Pettig, Ed.D. Education, University of Rochester, Instructional Challenge Coordinator, Pittsford Central School District, Pittsford, NY; Sherry Booth, M.Ed., Harvard University, Senior Mathematics Curriculum Developer and Teacher Trainer; Marianne Thompson; M.Ed., Harvard University; Middle School Math Teacher, Curriculum Developer; and Sue Vohrer, M.Ed., Johns Hopkins University, Mathematics Resource Teacher PreK-12, Baltimore County Public School

Number Worlds is an intensive intervention program that focuses on students who are one or more grade levels behind in elementary mathematics. It provides all the tools teachers need to assess students' abilities, individualize instruction, and build foundational skills and concepts. Number Worlds includes a prevention program for Grades Pre-K–1

Number Worlds provides instruction for students who are one to two grade levels behind their peers in mathematics. Lessons are designed to take 45-60 minutes. Because of the range of student proficiency, each level in Number Worlds may provide appropriate intervention for students in different grade levels. Using the Placement Test in Assessment combined with the Number Knowledge Test will effectively place students in the appropriate level and unit.

For students in grades 1-8 who are one or more grade levels behind in math, Number Worlds builds on students' current level of understanding with six 4-week intensive units per grade. At these grades, students may have difficulty with one, two, or many different math concepts. The goal of the Number Worlds units is to develop foundational understandings in each concept so that students develop on-level mathematical proficiency.

An Algebra Readiness program with the Number Worlds philosophy includes instruction for students who are not ready for algebra in grade 8 or 9. This course develops foundational concepts to prepare students for on-level work in algebra.

## **Transitional Math**

The Transitional Mathematics (TransMath) instructional program was developed by John Woodward and Mary Stroh and is published by Sopris West. The Transitional Mathematics (TransMath) program was designed and developed to provide explicit mathematics instruction for use in grades five through nine.

TransMath targets instruction to fewer topics in greater depth, so students master key foundational skills before moving on to more complex topics. Three levels in three years prepare students for algebra success. TransMath is a comprehensive program specifically designed to address the needs of struggling late elementary and middle school students.

The features of the TransMath instruction protocol include:

- \* Fewer topics in greater depth
- \* Numerous visual representations to help conceptualize the mathematics
- \* A focus on individual student needs
- \* A logical sequence, ample practice, and an appropriate pace

- \* Alignment with National Council of Teachers of Mathematics (NCTM) Standards
- \* Accurate placement and progress monitoring
- \* Ongoing professional development for teachers
- \* A balance between procedural knowledge and conceptual understanding

### **Wake County School Remedial Warm-ups/Focus Lesson Model**

Resource Math Classrooms are used to provide mathematics instruction for students identified with special needs. In this model of instruction teachers are asked to spend 25-40% of class time on remedial warm-ups and the rest of class time on Standard Course of Study Focus Lessons. For instance, a teacher with a seventy-minute class may use between 20 and 30 minutes on the Remedial Warm-ups and 40-50 minutes on the Standard Course of Study Focus Lessons.

The Remedial Warm-ups are hands-on activities that develop the students number sense for basic operations. Students are provided instruction in addition, subtraction, multiplication and division in the first year and progress to ratios/proportions and integers in the second year of implementation.

These topics are explored with an emphasis on the Components of Number Sense as outlined in *Teaching Exceptional Children* (2009, in press). The Standard Course of Study Focus Lessons were also developed in Wake County and are based on the Brazosport Texas model instruction wherein teachers are assured of covering the entire Standard Course of Study. The model project staff have developed lessons for a year built on the Standard Course of Study content. While in the general education classroom these lessons may take 15-20 minutes, teachers in the Resource Mathematics classroom utilize them as the Standard Course of Study lesson for the class period (40-50 minutes).

A few students (23) received mathematics instruction from Students receiving mathematics instruction from projects using either the Corrective Mathematics/Mathematics Mastery programs or the Wilson Mathematics System.

### **Instructional Group Size and Mathematics Progress**

Table 8 provides data comparing the size of the instructional group of students receiving research-based instruction and the percentage points gained by NCSIP students. If the total number of students in a specific group size was less than ten they were not included in the analysis. As can be seen in Table 8 the students receiving mathematics instruction in groups of three increased by twenty percentage points in the percentage of students at or above grade level from 2008 to 2009. However, students receiving instruction in a group of thirteen, the largest instructional group reported on in the data analysis, there was a gain of forty-four percentage points for students performing at or above grade level.

Students in all of the other instructional groups across the various size groups, with the exception of a group of seven, demonstrated increases in the percentage of students performing at or above grade level. The increases in percentage point gains for students in the other groups ranged from

a gain of thirty-five in a percentage point gain for an instructional group of eleven and a low of no percentage point gain for students in instructional groups of seven.

Table 8  
Gains in Mathematics By Group Size  
2008-2009

Group Size	N*	%AAGL* 2008	%AAGL* 200	Gain
3	18	17	37	20
4	22	9	14	5
5	46	22	33	11
6	36	33	53	20
7	19	37	37	0
8	42	33	52	19
9	26	23	50	27
10	18	17	17	0
11	17	18	53	35
13	25	12	56	44

\* % At or Above Grade Level

\*\*Total number of students below ten not included

As can be seen in Table 8 there appears to be little relationship between progress in mathematics skills with the size of the instructional group at thirteen and below.

Comment [N1]:

### Gains in Mathematics By Instructional Setting

As can be seen in Table 9 below a large majority of students received their mathematics instruction in resource rooms while whole group instruction in a regular classroom was used the least. Students placed in self-contained classrooms demonstrated the smallest percentage point gain while students placed in the regular class setting with whole group instruction made the highest gains.

All of the NCSIP instructional groups made excellent progress when compared to the progress made by all students with disabilities statewide. (10 All SWD and (12) all non-disabled

Table 9 presents the percentage point gains in the percentage of students at or above grade level from 2007 through 2008 across the five types of instructional settings used for mathematics instruction by the NCSIP project.

Table 9  
Gains in Mathematics By Instructional Setting  
2007 2008

Instructional Setting	N	%AAGL 2007*	%AAGL 2008	Gain
Self Contained	45	27	44	17

Resource/ Pull Out	197	22	40	18
Regular Class/ Sub-Group	25	32	60	28
Regular Class/ Whole Group	0	0	0	--

\*% At or Above Grade Lev

\*\* Number reporting below 10 students

It should be noted that the instructional setting is only one factor that impacts on the progress of students with serious mathematics problems. Other factors to consider are size of the instructional group, the perceived level of learning abilities, the instructional model used, and the fidelity of the instruction may all impact on the progress made by students.

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#### **SAS JMP statistical analysis program**