Research Watch
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MIDDLE SCHOOL ALGEBRA I: EFFECTIVE INSTRUCTIONAL STRATEGIES WITH COMPARISON TO HIGH SCHOOL PRACTICES

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ABSTRACT

This study examined practices of teachers in Wake County Public Schools' (WCPSS) middle school Algebra I classes. Regression analyses of standardized state testing results allowed for identification of the most effective and least effective Algebra I teachers. The study used surveys, observations, and focus group interviews to compare and contrast most effective teachers with less effective teachers. It found that the most effective middle school algebra teachers held a significantly more positive attitude toward their students than did less effective teachers. They had high expectations for ***all*** *students, used mathematics vocabulary appropriately, had a structured classroom management style, taught bell to bell using an invigorated pace, and had a classroom culture in which students were free to ask questions, contribute, and offer explanations. These results can be used to motivate teacher and school improvement efforts.*

INTRODUCTION

The importance of algebra in preparing students to be successful and productive citizens of the 21st century is now widely, if not completely, accepted. Moses (1995) named algebra "the new civil right." In *Principles and Standards for School Mathematics*, there is an algebra standard in all grade spans from Pre-K to 12. At the middle school level, grades 6 to 8, the National Council of Teachers of Mathematics (NCTM) proposes that students "learn significant amounts of algebra" (National Council of Teachers of Mathematics, Inc. [NCTM], 2000, p. 212).

Key Topics

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Despite this, there are still many areas of disagreement about the delivery of algebra. Current debates address three main topics: the definition of algebra, the content of an Algebra I class, and when should students first take Algebra I. Steen (1999) argued that there were "virtually insurmountable impediments" to all students studying algebra in eighth grade. The barriers that he identified included unprepared students, lack of readiness for the abstraction of algebra, a shortage of middle school teachers prepared to teach algebra, a lack of course materials, including textbooks, that appropriately bridged the transition from arithmetic to algebra, and teacher beliefs that most students cannot learn algebra in eighth grade. Despite these barriers, there has been a movement to require algebra of all eighth grade students. In 2008, California made algebra mandatory in eighth grade. However on October 28, 2008, a California Superior Court judge ordered the state Board of Education to stop all further plans until a December 19 court hearing. Proponents of eighth grade algebra argue that even low performing students learn more in an algebra course than in an eighth grade mathematics course, and that all students should have the opportunity to prepare to study advanced mathematics in high school (Mathews, 2008a, 2008b; Williams, 2008).

Those opposing eighth grade algebra for all are supported by a recent study of the Brookings Institution that found some students scoring in the bottom 10^{th} percentile on the National Assessment of Educational Progress (NAEP) eighth grade mathematics test who were also taking Algebra I or even geometry. The conclusion of this report is that there are many students in algebra who are misplaced. These students lack basic preparation and often turn the Algebra I class into a basic arithmetic skills class (Loveless, 2008). NCTM recently released a position paper that summarizes their stance on these controversial algebra discussions. It includes the following statement: "Exposing students to such coursework before they are ready often leads to frustration, failure, and negative attitudes toward mathematics and learning" (NCTM, 2008).

ALGEBRA IN NORTH CAROLINA

The North Carolina Standard Course of Study (NCSCS) reflects the NCTM algebra standard by incorporating algebraic concepts from Kindergarten to 12^{th} grade, and increasing amounts of algebra in grades six to eight (20%-25% of the curriculum in grade 6, 25%-30% in grade 7, and 35% to 40% in grade 8). The majority of the concepts regarding linear equations from the Algebra I 1998 NCSCS were moved to the eighth grade math curriculum in the 2003 NCSCS. Students study evaluating algebraic expressions, solving simple equations and inequalities, and solving problems involving rates of change in sixth grade; linear relationships and fundamental algebraic concepts in seventh grade; and detailed work with linear relationships including finding slope and equations of lines in eighth grade (North Carolina Department of Public Instruction [NCDPI], 1998, 2003a, 2003b, 2003c).

The official North Carolina Algebra I course of study reflects all the prior algebra goals in grades 6 to 8 as prerequisites. Although most students take Algebra I in high school, there are many academically advanced middle school students who master the mathematics goals of grades 6 to 8 before eighth grade (a rare few before sixth or seventh grades), and proceed to take the Algebra I course in middle school.

ALGEBRA I AND THE STATE ACCOUNTABILITY MODEL

In North Carolina, End-of-Course (EOC) exams are administered in 10 high school courses, including Algebra I. Each exam is a standardized multiple-choice test written with input from teachers across the state. Teachers participate in test development in a variety of ways, from writing the curriculum, on which EOC tests are based, to writing and reviewing test items. Each student who takes an EOC test is assigned a scale score based on the number of items correct and the difficulty of items. The scale scores are then converted to one of four levels of performance. Levels III and IV are associated with adequate or higher mastery of course content, and are considered proficient (NCDPI, 2007). The percentages of students passing each EOC in a school are reported publicly, and teachers often judge their own success using these percentages.

For middle schools, the Algebra I EOC tests administered each year are a small component of the ABCs of Public Education, the state's accountability program. The program actually has two measurement standards: the absolute percentage of tests at or above grade-level proficiency, and the attainment of "expected" growth. The basic assumption of the growth part of the model is that a student should be expected to do at least as well on each EOC test as the student's prior performance on End-of-Grade (EOG) and EOC tests. Teachers with high-achieving students do not always produce expected growth in their students. The expected growth measure is considered by most teachers to be a fairer measure of success than student proficiency alone, because it takes into account the skill set that students bring to the course (NCPDI, 2008).

WCPSS MIDDLE SCHOOL ALGEBRA I

Demographics

In 2007-08, 3,360 students (29% of all WCPSS Algebra I students) took Algebra I in middle school. Most of these students, 3,097, were in eighth grade. Most WCPSS middle school students prepare for Algebra I by taking a compacted mathematics course (Pre-Algebra) that covers both the seventh and the eighth grade mathematics curriculum during their 7^{th} grade year. Thirty percent of 2007-08 eighth grade students took Algebra I as their mathematics course. There were also five sixth grade and 258 seventh grade Algebra I students in 2007-08. By the end of 2007-08, 33% of WCPSS eighth grade students had taken Algebra I. This is the same percentage as North Carolina as a whole, but a little lower than the national average of 38% (Loveless, 2008).

The ethnic enrollment of 2007-08 middle school Algebra I was 69.8% White, 10.1% Asian, and 16.5% Black/African American or Hispanic/Latino. There were slightly more males than females (50.5% compared to 49.5%). The overall 8^{th} grade mathematics enrollment was 52.4% White, 5.3% Asian, and 38.0% Black/African American or Hispanic/Latino with 51.5% male and 48.5% female (Table 1).

Table 1
WCPSS Middle School Algebra I Enrollment by Gender and Ethnicity
2007-08

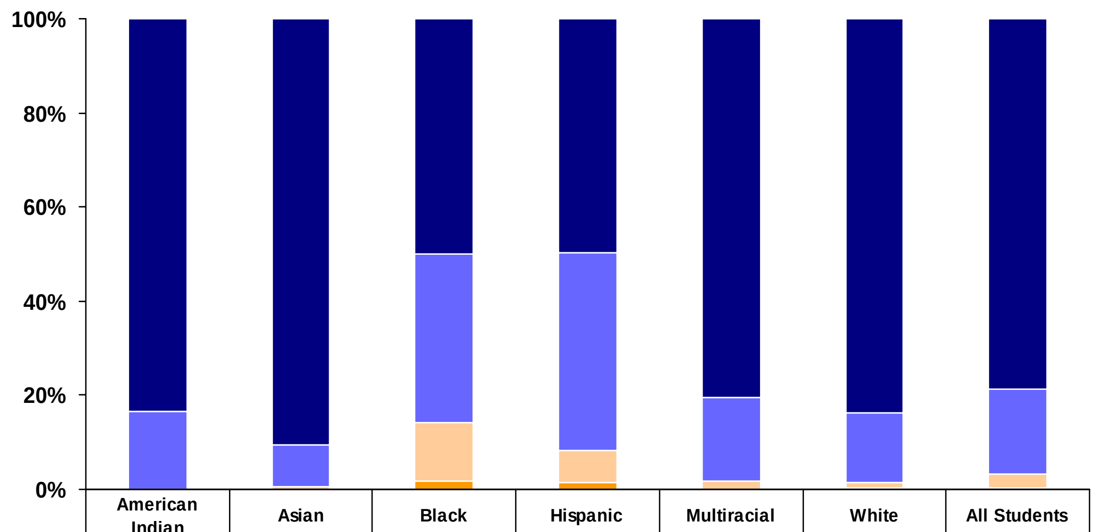
	Algebra I						8th grade Math					
	Male		Female		Total		Male		Female		Total	
	n	% of course	n	% of course	n	% of course	n	% of course	n	% of course	n	% of course
American Indian	4	0.1%	2	0.1%	6	0.2%	18	0.2%	12	0.1%	30	0.3%
Asian	173	5.1%	167	5.0%	340	10.1%	289	2.9%	239	2.4%	528	5.3%
Black/African American	160	4.8%	245	7.3%	405	12.1%	1419	14.3%	1403	14.1%	2822	28.4%
Hispanic/Latino	75	2.2%	72	2.1%	147	4.4%	483	4.9%	470	4.7%	953	9.6%
Multiracial	65	1.9%	53	1.6%	118	3.5%	208	2.1%	186	1.9%	394	4.0%
White	1221	36.3%	1123	33.4%	2344	69.8%	2697	27.2%	2503	25.2%	5200	52.4%
All Students	1698	50.5%	1662	49.5%	3360	100.0%	5114	51.5%	4813	48.5%	9927	100.0%

Student Performance and Growth

Middle school Algebra I students are good students who perform well and out perform their high school peers. In 2007-08, 97% of middle school Algebra I students scored at Level III or IV (the proficiency levels) on the EOC exam (Asian, 99%; Black/African American or Hispanic/Latino, 88%; and White, 98%). Seventy-nine percent of these students scored at Level IV (Asian, 91%; Black/African American or Hispanic/Latino, 50%; and White, 84%).

The distribution of scale scores is slightly skewed left with a mean of 164 compared to the high school distribution that is more bell-shaped with a mean of 152 (Figures 1 – 3).

Figure 1
Level Performance of 2007-08 Middle School Algebra I Students



	American Indian	Asian	Black	Hispanic	Multiracial	White	All Students
Level IV	5	308	203	73	95	1962	2646
Level III	1	30	145	62	21	344	603
Level II	0	2	50	10	2	34	98
Level I	0	0	7	2	0	4	13

Figure 2
2007-08 Distribution of Middle School Algebra I Scale Scores

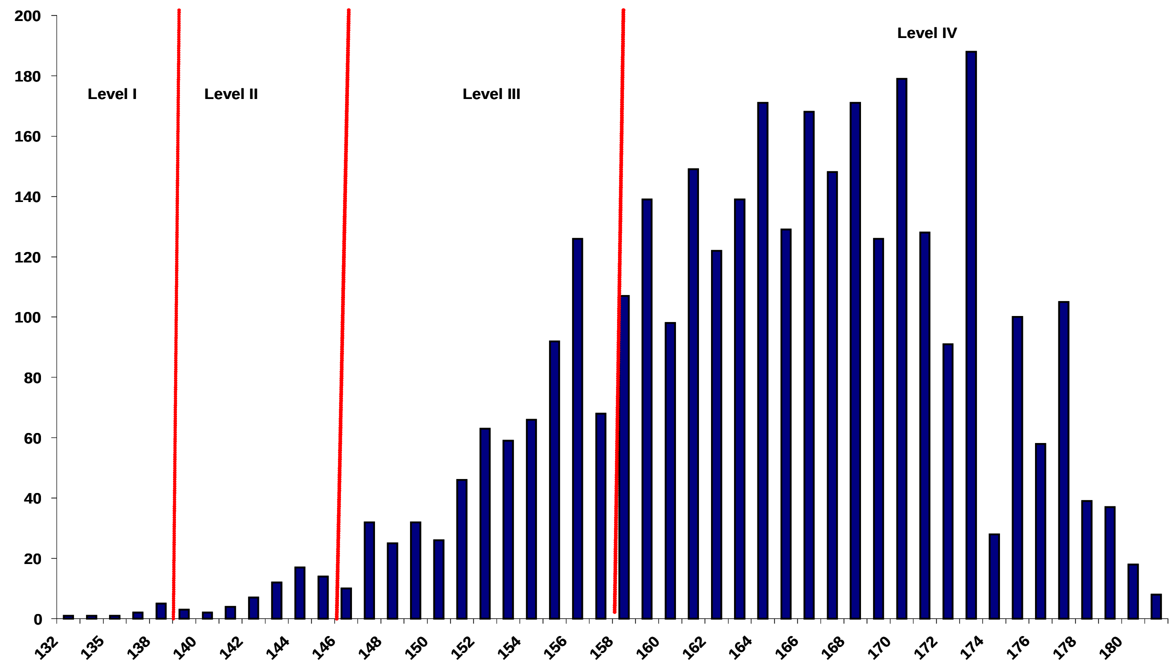
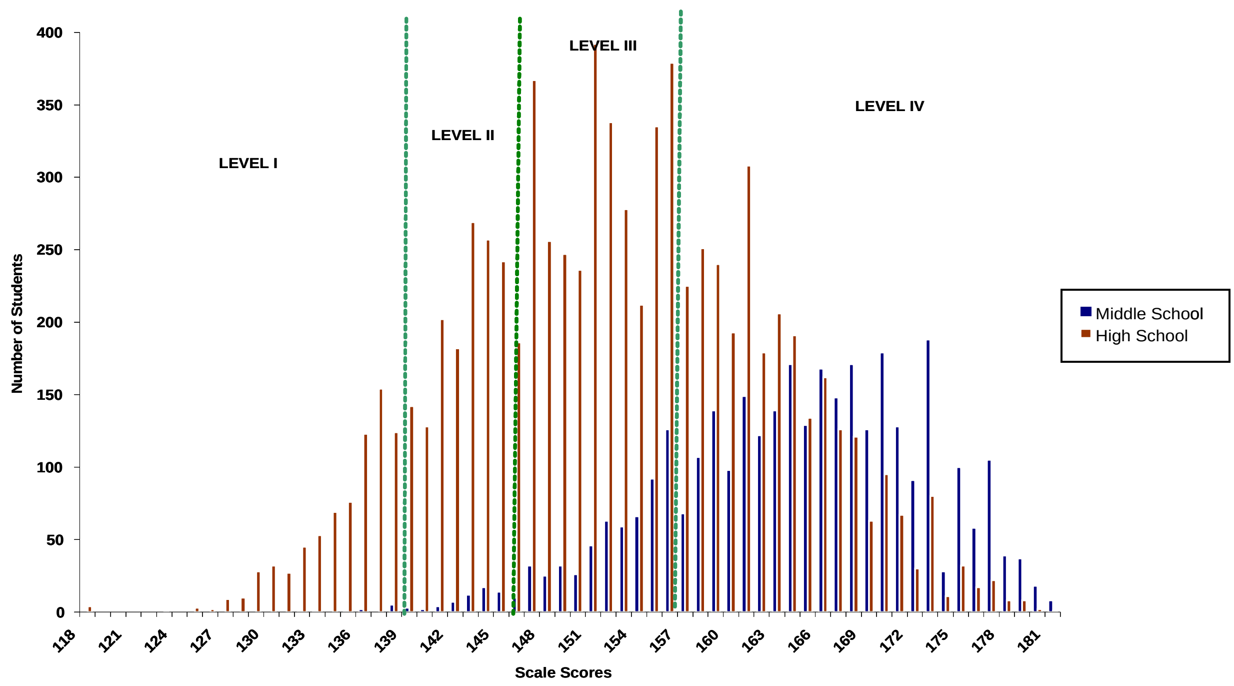


Figure 3
Comparison of 2007-08 Middle School and High School Scale Score Distributions



As shown in Table 2, percentages of proficient students in 2007-08 ranged from 84.5% to 100%. Of 28 middle schools, the percentages of students who met their North Carolina expected growth target ranged from 21.7% to 89.2%. All but nine schools had 60% or more, thus making high growth. Yet six of the nine schools with less than 60% did not make expected growth either. Moreover, four of the schools that had more than 90% of their students proficient did not meet high growth. The growth percentages reveal an area where improvement can be made. To reach the WCPSS goal of "all students demonstrating high academic growth and graduating on time prepared to compete globally", schools need to set the goal of all Algebra I students maximizing their performance, not just reaching minimum proficiency (Table 2). Note that two new middle schools had only a sixth grade, and did not offer Algebra I in 2007-08. Three other middle schools were alternative schools and are also excluded here.

Table 2
2007-08 Performance and Growth by Middle School

School	Proficiency School Rank	% Proficient	% Making Growth Target	High Growth	Growth School Rank
A	1	100.0	89.2	met	1
B	1	100.0	86.4	met	2
C	1	100.0	79.9	met	5
D	1	100.0	78.5	met	7
E	1	100.0	74.4	met	9
F	1	100.0	72.2	met	12
G	7	99.4	84.2	met	3
H	8	99.3	66.9	met	15
I	9	99.2	81.2	met	4
J	10	99.1	76.3	met	8
K	11	98.6	72.9	met	11
L	11	98.6	65.4	met	16
M	11	98.6	61.6	met	19
N	11	98.6	43.1	not met*	26
O	15	97.7	73.4	met	10
P	16	97.1	64.7	met	17
Q	17	96.9	79.6	met	6
R	18	96.7	64.4	met	18
S	19	96.4	57.7	not met	21
T	20	95.0	67.1	met	14
U	20	95.0	48.2	not met*	24
V	22	92.5	52.9	not met	22
W	23	92.4	68.2	met	13
X	24	89.9	58.7	not met	20
Y	25	89.3	45.6	not met*	25
Z	26	88.0	21.7	not met*	28
AA	27	87.0	41.2	not met*	27
BB	28	84.5	48.4	not met*	23

* did not make expected growth

IMPORTANCE OF TEACHER QUALITY TO STUDENT SUCCESS

The performance of students on the standardized EOG and EOC exams is not only used in the North Carolina ABCs but also as the main measure of the success of the federal Elementary and Secondary Education Act of 1965 (ESEA), amended by the No Child Left Behind Act of 2001 (NCLB). Several studies of student gains on standardized tests from one year to another have found the student's assigned teacher to be the most influential factor (Rivkin, Hanushek, & Kain, 2001; Sanders & Horn, 1994; Sanders & Rivers, 1996; Wright, Horn, & Sanders, 1997).

Over the past twenty years, the importance of the classroom teacher has emerged as a key component of school reform. In 1987, the National Board for Professional Teaching Standards was established with a mission of advancing the quality of learning by advancing the quality of teaching. In 1989, the National Board issued a policy statement, *What Teachers Should Know and Be Able to Do* (National Board for Professional Teaching Standards [NBPTS], 1989), which posited five core propositions to guide the certification of National Board Teachers:

- commitment to students and learning,
- knowledge of the subject taught and effective methods of teaching it,
- responsibility for managing and monitoring student learning,
- systematic reflection on practice that leads to improved practice, and
- membership in a learning community.

NCLB also emphasizes teacher quality (U.S. Congress, 2001). Under NCLB, every state must develop and implement a plan to insure that all students will be taught by a "highly qualified teacher" (HQT; sec.2101). Margaret Spellings, U.S. Secretary of Education, stated in a letter dated October 21, 2005, "There is also evidence that states are improving the quality of their teaching forces." She wrote that the U.S. Department of Education was committed to the goal of every child being taught by an HQT by the end of 2005-06, and then outlined the actions that would be taken to support states in reaching this goal (Spellings, 2005). The NCLB law requires that all academic core subject teachers be highly qualified. The NCLB law (U.S. Department of Education, 2006) uses three key guidelines to determine whether a teacher is highly qualified:

- at least a bachelor's degree in the subject taught,
- full state teacher certification, and
- demonstrated knowledge in the subject taught.

The importance of teachers is recognized by national subject-specific professional teaching organizations. NCTM in *Principles and Standards for School Mathematics*, details requirements of effective teaching, including the requirement to continually seek improvement. "The improvement of mathematics education for all students requires effective mathematics teaching in all classrooms" (NCTM, 2000, p. 17).

MIDDLE SCHOOL ALGEBRA TEACHERS

Steen's (1999) concern that there is a shortage of middle school teachers prepared to teach algebra was supported in 2007 by a new study conducted by researchers from Michigan State

University funded by a National Science Foundation Grant. Led by William H. Schmidt, the research found that United States middle school mathematics teachers were not as well-prepared to teach mathematics as middle school teachers in five other countries (South Korea, Taiwan, Germany, Bulgaria, and Mexico). Algebra knowledge was particularly lacking with prospective U.S. teachers scoring at the bottom of all countries in the study (a full standard deviation below Taiwan). In the U.S., middle school mathematics teachers are prepared in one of three programs (secondary, middle, or elementary). Teachers trained in a secondary program were strongest in content with those from elementary programs strongest in pedagogy. The middle school programs were weaker in both areas. Teachers from elementary or middle school programs were more likely to view mathematics as algorithmic than teachers from a secondary preparation (Schmidt et al, 2007).

In Arkansas, where middle school teachers are certified with a general certificate across subjects for grades 4 to 8, middle school teachers must now earn a state endorsement in algebra to teach Algebra I . The new requirement can be met after completion of a 15-hour program of advanced mathematics study including calculus and a minimum score on the Praxis II for middle school mathematics. Until now, Arkansas has only allowed teachers with a high school mathematics license to teach middle school Algebra I. Some middle school Algebra I students had to travel to a high school or be taught by a borrowed high school teacher (Cavanagh, 2008).

In North Carolina, a mathematics middle grades licensure includes Algebra I. Licensed teachers have completed 24 hours of mathematics, successfully passed the Math Praxis, and graduated from a recognized college or university.

MEASUREMENT OF TEACHER QUALITY

Student standardized test performance has been a commonly used measure of teacher quality. In North Carolina, the state provides to every school district test analysis software that can be used to run school-level results and results for subgroups of students within the school. The state also posts these disaggregated test results on a web site. These analyses, however, are limited to average scale scores, percentages of students tested who attain proficiency, and state growth measures. Although these state-provided measures serve as a valid way of reporting how teachers and schools are succeeding, the WCPSS Evaluation and Research department has developed more fine-grained methods to determine which schools and teachers are getting the most growth with students *in comparison to other WCPSS students*. Identifying the schools and teachers that are getting the highest performance from students at varying levels of preparation is necessary in order to be able to share best practices within the district and motivate school improvement efforts.

WCPSS Residuals and Effectiveness Index

Since the early 1990s, WCPSS has used a multiple regression analysis to generate an "effectiveness index" that measures achievement at each school within WCPSS. The regression analysis creates a prediction model by using the current year's test scores as the outcome and previous years' test scores as the predictors. The analysis also takes into account each student's special program status level of service (e.g. self-contained), free or reduced-price lunch (FRL) status, and academically gifted (AG) status as well as the percentage of FRL students in the school. A residual score is calculated for each WCPSS student who took the test and had the necessary previous test scores to use as predictors. The residual score for a student is the difference between the student's actual score and the score that the regression analysis model predicted. These residuals measure how students performed compared to other students in WCPSS with similar previous test scores and program identifiers.

As an example, Figure 4 gives a simplified visual of the regression analysis for Algebra I with three of the many possible lines. It shows that the predictions are both dependent on previous EOG and/or EOC scores and also the student's program characteristics, such as AG or a student with a disability (SWD) in a resource setting who is also FRL. The middle line could represent students with no identifiers (e.g., typical students).

Figure 4

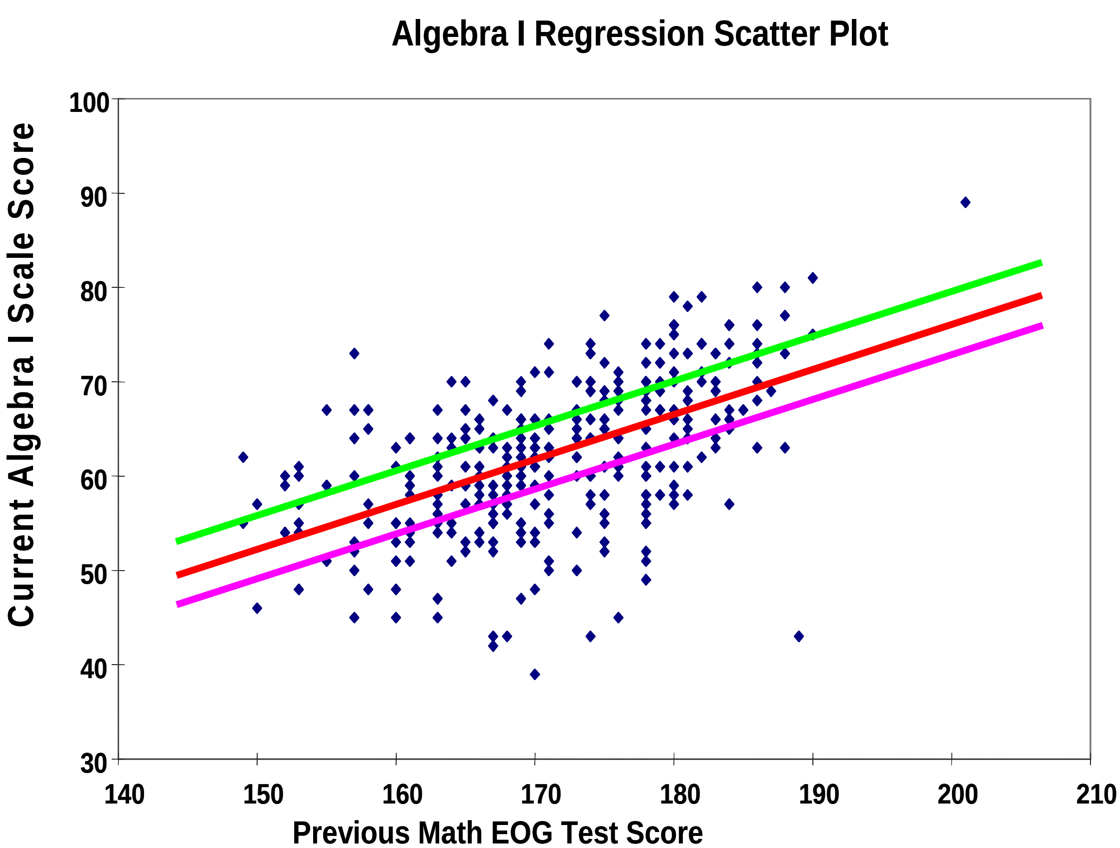
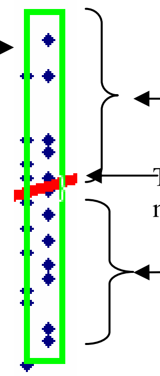


Figure 5 shows one vertical slice of the regression model for students whose prediction line is the middle line of Figure 4 and whose previous math EOG score was 170. Therefore, they share the exact profile on all of the factors used to predict the outcome. The line at the center is the predicted score generated by the model for these students. A residual is the difference between the actual score and the predicted score. Scores above the red line have positive residuals and scores below have negative residuals.

Figure 5
Student Residuals for a Hypothetical Group of Students



For each test given, the residuals are averaged across all students in the school, and a standardized z-score (effectiveness index) is generated for each school by subject. A z-score is the number of standard deviations that the school's residual average is from the average (mean) of all the schools with at least 30 students who have test scores and previous scores. If the z-score is greater than 1, then the school knows that its students in that course have scored significantly higher (among the top 16%) than other students in the district after taking into consideration their previous test scores and program characteristics. Similarly, if the effectiveness index is less than -1, then the students have scores much lower (among the bottom 16%) than other students in other schools. Values between –1 and +1 are within one standard deviation of the district average and are considered "typical" or expected (68% of scores should be in this range).

In addition to the school's z-scores, WCPSS principals receive rosters of student residuals by teacher, course, and section. In these rosters, student residuals above one standard deviation are coded in green, and student residuals below one standard deviation are coded in red. The standard deviation in scale-score points of these residual scores is displayed at the bottom of roster, along with the average residual for the section.

Table 3 is a sample roster for a 2006-07 middle school Algebra I class of 18 students. For each student, the predictor scores are shown. The predictors for the Algebra I EOC were the 7th-grade reading and mathematics scores. The roster then displays the Algebra I EOC scale score and the residual score for each student. These residuals are averaged and an average residual score for the class is provided. The average residual for this class was 0.30. The principal and teacher can then determine how successful students were on the EOC as compared with other students with similar characteristics. Notice that Student 8, Student 12, and Student 16 have the same scale score on the Algebra I EOC exam, but Student 8 has a negative residual while Student 12 and Student 16 have positive residuals. Student 16 has lower scale scores on the 7th grade EOG exams than Student 8 thus explaining the much higher residual. The residual shows a measure of performance as related to previous performance and other educational indicators, and gives a sense of the relative growth for each student. Student 1 has no residual, as this student is missing previous test scores required to calculate a residual.

Table 3
Sample Middle School Algebra I EOC Residual Roster

Name	7th-Grade EOG Reading Scale Score	7th-Grade EOG Math Scale Score	2007 A1 Scale score	2007 A1 Residual
Student 1	.	.	179	.
Student 2	264	366	152	-7.74
Student 3	262	370	158	-5.77
Student 4	277	370	163	-3.07
Student 5	268	372	162	-2.60
Student 6	276	375	167	-2.29
Student 7	269	369	162	-2.02
Student 8	271	376	168	-1.32
Student 9	274	379	171	-1.12
Student 10	272	371	164	-0.43
Student 11	281	382	175	-0.24
Student 12	272	373	168	0.46
Student 13	267	372	165	1.57
Student 14	274	374	170	3.14
Student 15	281	372	170	3.61
Student 16	268	368	168	6.28
Student 17	267	374	173	7.11
Student 18	267	370	174	9.54

Note: Class Average = 0.30
Standard deviation = 5.09
Interpretation Example: Student 16 had a 7th-grade reading scale score of 268 and a 7th-grade mathematics scale score of 368. Student 16's 2007 Algebra I scale score was 168 and the student's residual was 6.28. This student scored among the top 16% of students with the same Algebra I score, the same 7th-grade mathematics scores and the same academic program indicators.

WCPSS Middle School Effectiveness

Table 4 shows the Algebra I effectiveness indices of 26 WCPSS middle schools in 2004-05, 2005-06, 2006-07, and 2007-08 (two of the previous 28 schools were new and did not have data for three prior years). Schools with an effectiveness index above 1 are coded as H for high and below a -1 as L for low. Schools with effectiveness indices between -1 and 1 are coded with an M. The schools were ordered with the same identifying letter as in Table 2, thus in order from highest percentage proficient to lowest. Since middle schools have an average of three to four Algebra I teachers per school, the performance of each teacher contributes significantly to the overall school effectiveness.

Table 4
School Level WCPSS Effectiveness Indices

School	04-05	05-06	06-07	07-08
A	M-	H	M+	H
B	L	H	M+	M+
C	M-	M+	M-	M-
D	M-	L	L	M+
F	H	H	M-	H
G	M+	H	M+	M+
H	M+	M+	M+	M-
I	L	L	M-	M-
J	H	H	H	M+
K	H	H	M-	M+
L	M-	M+	M+	M-
M	L	M+	M-	M+
N	M-	M+	H	L
O	M+	H	H	M+
P	H	L	H	H
Q	L	L	M-	M+
R	L	L	M-	M-
T	M-	L	L	M+
U	M+	M+	L	L
V	L	L	M-	M-
W	M+	M+	M-	M+
X	H	L	M-	M+
Y	H	H	H	M-
Z	L	L	M+	L
AA	L	M-	L	M-
BB	L	M+	M-	M-

Note:
1. H = effectiveness index > 1
2. L = effectiveness index < -1
3. M+ = effectiveness index between 0 and 1
4. M- = effectiveness index between -1 and 0

PURPOSE OF STUDY

This research study had two main objectives:

- Study middle school Algebra I using a WCPSS Value-Added Instructional Improvement Analysis Model.
  - ► Collect WCPSS-specific data that will help teachers, schools, and district leadership understand their current practices in middle school Algebra I.
  - ► Identify and share best teaching strategies in middle school Algebra I that are linked to high student achievement.

- Contribute to a series of studies that identify targets for overall systemic improvement.
  - ► Identify the roles of teachers, academic departments, principals, schools, and central services' administrators in the school improvement process.
  - ► Identify the practices of effective instruction.

The classroom practices of the most successful teachers can be documented to challenge teachers of middle school Algebra I students to even higher academic goals. Teacher performance evaluation was not a goal of this study, unlike most current valued-added models (Braun, 2005; Olson, 2005; Olson, 2004a, 2004b; Sanders, 1998; Tucker & Stronge, 2005). This study demonstrates the use of value-added research for teacher and school improvement rather than for purposes of teacher evaluation.

METHOD

Success in this study was defined by using the residuals generated from the WCPSS effectiveness study of the state Algebra I EOC standardized tests. The study brought value-added meaning to the middle school Algebra I EOC test performance. The student residual scores and the effectiveness indices give the district a comparison basis for schools and students. Until recently, residuals had not been averaged or standardized at the teacher level beyond the classroom roster. Prior to 2005-06, teachers were encouraged to study their rosters for trends in student performance, and some principals had compared teachers within their school, but no districtwide comparisons had been made. A study of biology teaching by WCPSS in 2004-05 (Haynie, 2006) was a first attempt at identifying the success of teachers, as indicated by average residuals, and then to identify the specific aspects of the practice of highly effective and relatively less effective teachers in order to isolate teachers' classroom practices that may be associated with high student achievement. Residual averages by teacher were also used in this study to identify teachers to observe.

This study was a collaborative study between the WCPSS Curriculum and Instruction Department (C&I) and the Evaluation and Research Department (E&R), with the goal of identifying best teaching practices. Since the effectiveness indices and teacher residual averages both use residual values that are calculated using student test results, that are known to contain error, three consecutive years of data were combined to both reduce the test error and remove inexperienced teachers and teachers who taught Algebra I infrequently. Specialists from C&I

took the lead in interpreting classroom observations while a specialist from E&R took the lead in data collection and analysis.

CONTEXT AND PARTICIPANTS

This research study took place in WCPSS, a large urban/suburban school district in North Carolina. The WCPSS student population is growing rapidly, with an enrollment of approximately 134,000 in 2007-08 with 29,975 middle school students. There were 33 middle schools in the district, of which eight were year-round, nine were magnet schools, and three were alternative. Excluding the alternative middle schools, there were twenty-eight middle schools that offered Algebra I in 2007-08.

The study began in 2006-07 by identifying 36 middle school Algebra I teachers (42% of all middle school Algebra I teachers) who had taught Algebra I in 2003-04, 2004-05, and 2005-06 and were teaching in 2006-07, which made them eligible for this study. For these 36 teachers the average student residual across all years and classes was calculated. The teachers were ranked on teacher effectiveness from highest to lowest using these averages. The teachers with the eight highest residual averages were labeled T1-T8 ("top" teachers) and the teachers with the eight lowest averages were labeled B1-B8 ("bottom" teachers). The practice of these 16 teachers became the focus of this study.

Table 5 shows the residual average (in scale score points), the residual standard deviation, the number of students, and the percentage of minority (Black/African American or Hispanic/Latino) students included in the average. The school code used was randomly assigned and not the same as in Tables 2 or 4. Table 5 demonstrates several points:

- The top 8 teachers were in 8 schools.
- The bottom 8 teachers were in 6 schools.
- Residual averages ranged from -4.07 to 5.02.
- The largest Black/Hispanic minority presence was in T1's classes with 36%, followed by T4, B2, B6, and B1 at 19%, 13%, 13%, and 11%.
- The lowest Black/Hispanic minority presence was in the classes of T8, B4, and B5 at 2% each.

Table 5
Residual Averages of Study Teachers

teacher	school	A1 Residual Mean	A1 Residual Standard Deviation	3-Year Residual N	% Black/ Hispanic
T1	S4	5.02	4.85	140	36%
T2	S9	4.15	4.05	129	5%
T3	S12	2.90	5.40	112	5%
T4	S5	2.37	5.55	119	19%
T5	S2	2.29	4.80	209	3%
T6	S6	1.79	4.88	100	6%
T7	S7	1.74	5.05	96	5%
T8	S13	1.41	5.06	118	2%
B8	S11	-0.30	5.64	121	5%
B7	S14	-0.46	4.81	155	10%
B6	S10	-1.18	5.04	94	13%
B5	S1	-1.87	4.98	101	2%
B4	S1	-2.37	4.91	114	2%
B3	S10	-2.66	4.50	120	9%
B2	S3	-2.99	5.86	103	13%
B1	S8	-4.07	4.69	97	11%

Overall the mean of the top teacher residual averages was 2.77 and for the bottom teachers it was -1.88. The difference between top and bottom teacher residual averages was also present when the residuals were disaggregated by ethnicity (Table 6).

Table 6
Residual Averages by Selected Ethnic Subgroups

group	Overall Residual Mean	Overall RES_SD	White Residual Mean	White RES_SD	Asian Residual Mean	Asian RES_SD	Black Residual Mean	Black RES_SD
TOP Teachers	2.77	5.07	2.49	5.02	4.5	4.78	3.65	5.81
BOTTOM Teachers	-1.88	5.19	-1.99	5.23	0.82	4.52	-2.23	4.89

INSTRUMENTS, DATA COLLECTION, AND ANALYSIS PROCEDURES

In addition to student achievement scores, four other types of data were collected for this study. First, a survey was prepared and distributed to the 36 study teachers. The teachers answered 37 written survey questions concerning preparation, planning, use of time, schedules, use of data, and student interaction.

Second, principal investigators for this study made classroom observations of all 16 teachers identified as most effective ("top teachers") or least effective ("bottom teachers"). All but one of the 16 teachers were observed by the Evaluation and Research senior administrator. The senior administrator from Curriculum and Instruction who began the project left for a new position out-of-state before the first scheduled observations in 2006-07. When the position was filled, the new senior administrator and the middle school mathematics coordinating teacher made 14 observations in 2007-08. Two teachers had left WCPSS middle school algebra. The observation instrument was adapted from the one previously used in the high school algebra study (Haynie, 2008).

Third, teacher focus-group interviews were conducted of the top teachers and the bottom teachers. All data collection instruments had some common questions or observations with the high school algebra study so comparison would be possible. Fourth, data were collected on cohorts of students from the top and bottom middle school and high school teachers as these students moved through high school mathematics.

RESULTS

STUDENTS

Prior Academic Achievement

Prior performance of students on 7th-grade mathematics EOG state tests was averaged for each of the top and bottom teachers. Table 7 shows the averages and the standard deviations. For the years 2003-06, the overall average 7th-grade mathematics scale score ranged from 278.9 to 288.5 for top teachers and 279.1 to 287.9 for bottom teachers. The overall average was 284.5 for top teachers and 284.0 for bottom teachers. The EOG mathematics test was rescaled in 2005-06. Yet for the year 2005-06, scale conversions to the past scale were available and so averaged with the previous years. These conversions were not available in 2006-07, so the averages are reported on the new scale. The top teachers' 7^{th}-grade scale score average in that year was 371.7 and the bottom teachers' average was 370.8.

The top teacher, T1, had the lowest previous 7^{th}-grade test score averages; closest to the averages of teachers B1, B2, and B7. Teachers T2, B4, and B5 had the highest previous test score averages. The overall averages of top and bottom teachers were within 0.5 and 0.9 scale score points (Tables 7 and 8).

Table 7
7th-grade Student EOG Mathematics Averages
2003-2007

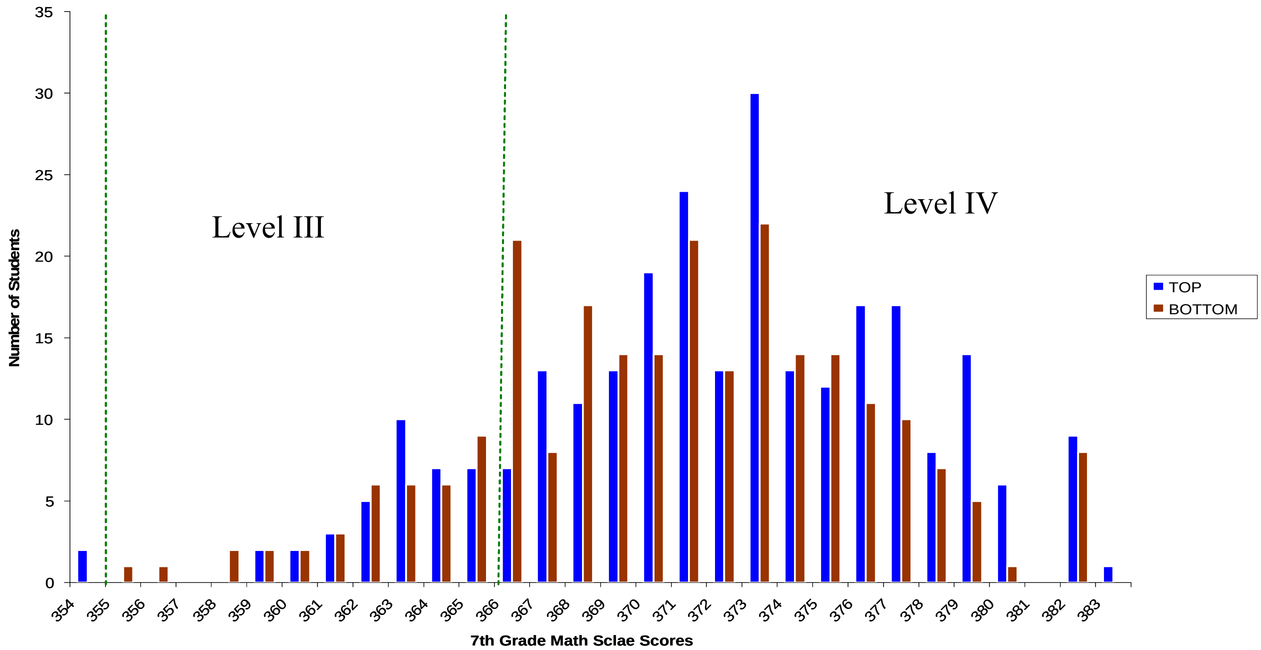
teacher	school	Average 7th grade Math EOG Scale Score 03-06	7th grade Math EOG Standard Deviation 03-06	Average 7th grade Math EOG Scale Score 06-07	7th grade Math EOG Standard Deviation 06-07
T1	S4	278.9	7.5	366.7	5.5
T2	S9	288.5	6.2	373.0	4.8
T3	S12	286.2	6.4	372.4	4.5
T4	S5	282.3	7.9	370.7	5.6
T5	S2	284.5	7.5	372.9	5.1
T6	S6	286.4	6.2	373.7	4.8
T7	S7	283.8	7.7	371.9	5.4
T8	S13	286.1	7.0	373.8	3.8
B8	S11	285.6	5.8	372.5	5.1
B7	S14	279.1	6.7	367.8	5.5
B6	S10	285.8	6.8	371.6	4.0
B5	S1	287.9	6.1	374.5	3.7
B4	S1	287.7	6.2	372.8	4.4
B3	S10	285.7	6.5	372.0	4.5
B2	S3	280.9	7.2	369.3	4.7
B1	S8	280.9	6.6	366.6	4.7

Table 8
Overall 7th-grade Student EOG Mathematics Averages
2003-2007

group	Average 7th grade Math EOG Scale Score 03-06	7th grade Math EOG Standard Deviation 03-06	Average 7th grade Math EOG Scale Score 06-07	7th grade Math EOG Standard Deviation 06-07
TOP	284.5	7.59	371.7	5.49
BOTTOM	284.0	7.23	370.8	5.20

Despite variation between teachers on previous student math test scores, there is little overall difference between the incoming student test scores of top and bottom teachers. Figure 6 compares the distribution of previous 7th grade mathematics scale scores for the top and bottom teachers. Both distributions show the same slightly skewed left pattern of scores with a similar mean and standard deviation.

Figure 6
Previous 7th Grade Mathematics EOG Scale Scores
2006-07



Notes: Top: Mean 371.7 Standard Deviation 5.49 Median 372
Bottom: Mean 370.8 Standard Deviation 5.20 Median 371

Algebra I Academic Achievement

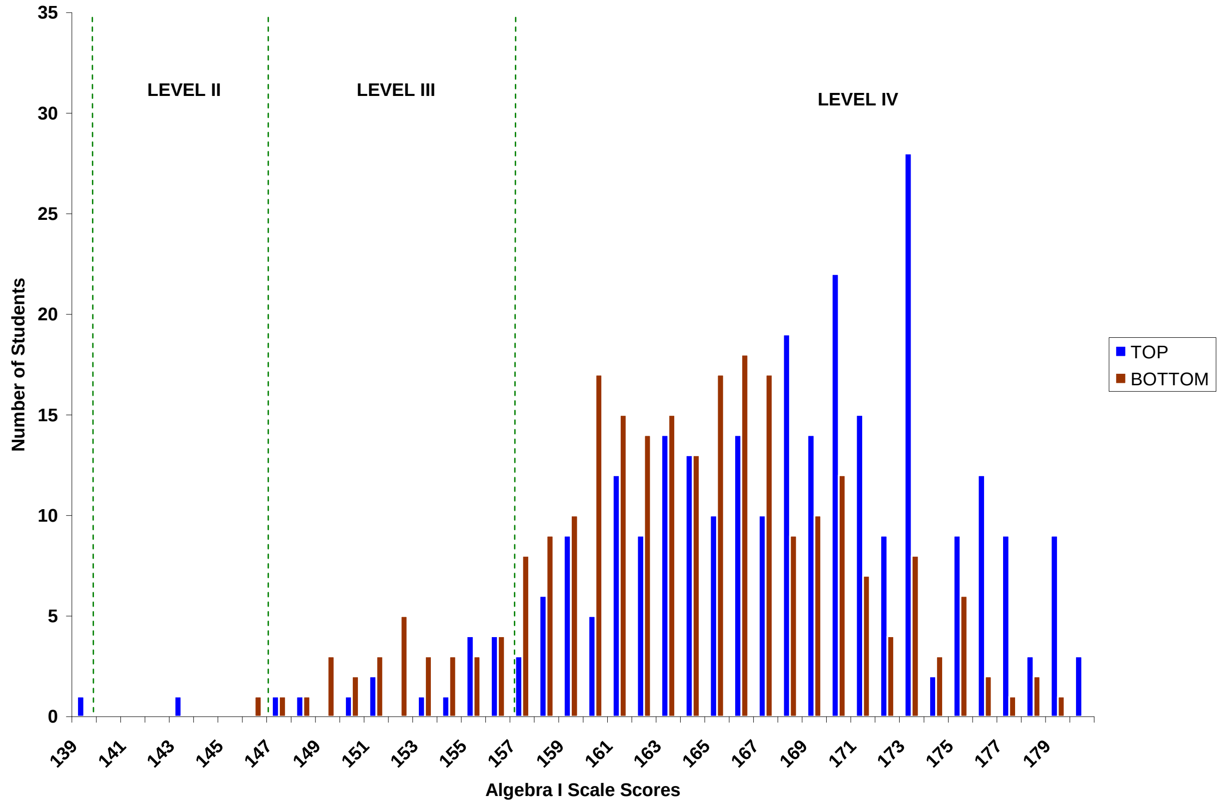
The overall percentage of students scoring proficient at Level III or Level IV on the Algebra I EOC varied from 97% to 100% among all top and bottom teachers. The difference between top and bottom teachers' student performance only becomes evident by studying performance at Level IV. The percentage of students scoring at Level IV ranged from 86% to 100% for top teachers and from 65% to 98% for bottom teachers. There was also a difference between the percentage of students scoring at the top half of Level IV. The top teachers percentages ranged from 22% to 64% and the bottom teachers from 5% to 38%. These percentages are shown in Table 9.

Table 9
Algebra I EOC Results by Teacher
2003-07

teacher	school	% At Level III or IV on Algebra I EOC	% At Level IV on Algebra I EOC	% At High Level IV on Algebra I EOC
T1	S4	99%	88%	22%
T2	S9	100%	100%	64%
T3	S12	100%	99%	44%
T4	S5	99%	86%	27%
T5	S2	100%	98%	39%
T6	S6	100%	98%	42%
T7	S7	99%	92%	39%
T8	S13	100%	98%	48%
B8	S11	99%	98%	38%
B7	S14	99%	80%	11%
B6	S10	100%	97%	27%
B5	S1	100%	94%	35%
B4	S1	100%	97%	23%
B3	S10	99%	91%	27%
B2	S3	97%	67%	14%
B1	S8	99%	65%	5%

Overall 99.6% of students in top teachers' classes scored proficient compared to 99.1% in bottom teachers classes. At Level IV, there were 95% of top teachers' students compared to 86% of bottom teacher students. At the top half of Level IV, the comparison percentages were 52% to 27%. The distribution of Algebra I scale scores was skewed left for both top and bottom teachers, but the mean of the top distribution (167.6) was 3.9 scale points higher than the bottom mean of 163.7 even though the previous 7th grade tests were comparably the same (Figure 7).

Figure 7
Algebra I EOC Scale Scores
2007-08



Notes: Top: Mean 167.6 Median 168
Bottom: Mean 163.7 Median 164

TEACHERS

In addition to the achievement described above, the 16 teachers in the full study were also surveyed on a variety of topics. The next section of the report focuses on those survey data and the difference between top and bottom teachers.

Survey Results – Educational Preparation

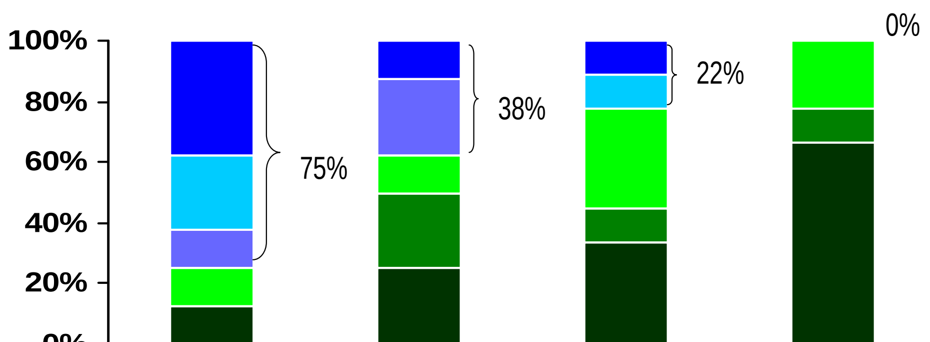
Five of eight top middle school teachers and six of eight bottom teachers held only a Bachelor's degree in mathematics or mathematics education. Three of eight top and two of eight bottom teachers also had an advanced degree in mathematics or education. Three of eight top and two of eight bottom teachers were nationally board certified. Not only was there no difference between top and bottom middle school teachers with respect to education, but the high school Algebra I teachers from the previous study (Haynie , 2008) reported the same levels of educational preparation. See Appendix A for the details by teacher.

Survey Results – Teaching Experience

The number of overall years of teaching experience ranged from 10 to 36 years for top teachers and from 7 to 37 years for bottom teachers. Seventy-five percent of top teachers had more than 20 years of teaching experience compared to 38% of bottom teachers. In teaching Algebra I, the years of experience ranged from 4 to 30 years for top teachers and from 4 to 24 years for bottom teachers. Most teachers, top and bottom, had less than 21 years of teaching Algebra I (63% of top teachers and 88% of bottom teachers).

Compared to the high school results (Haynie, 2008), middle school Algebra I teachers had more overall teaching experience than high school Algebra I teachers, with top teachers more experienced than bottom teachers in both middle and high. Teachers in the study had less Algebra I teaching experience than their overall teaching experience, with middle school teachers more experienced than high school teachers, and top teachers more experienced than bottom teachers. Despite the differences in experience, there were teachers with only the minimum of four consecutive years in all four groups top and bottom (see Figures 8 and 9). See Appendix A for the details by teacher.

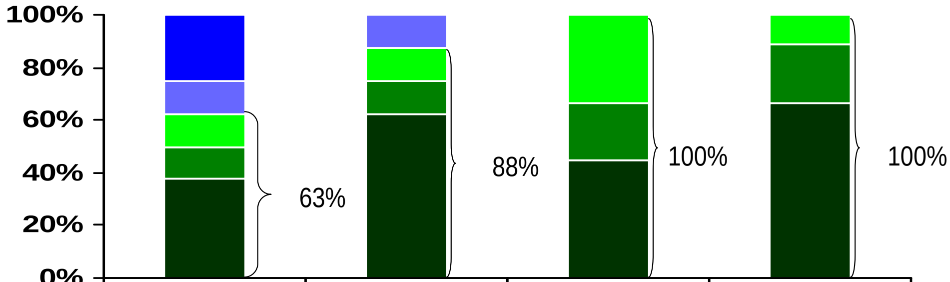
Figure 8
<u>Overall</u> Teaching Experience (Years)
Middle and High School Teachers



	Middle School Top Teachers	Middle School Bottom Teachers	High School Top Teachers	High School Bottom Teachers
>30	3	1	1	0
26-30	2	0	1	0
21-25	1	2	0	0
16-20	1	1	3	2
11-15	0	2	1	1
4-10	1	2	3	6

Notes: Blue represents more than 20 years of experience.
Green represents 20 or less years of experience.

Figure 9
<u>Algebra I</u> Teaching Experience (Years)
Middle and High School Teachers



	Middle School Top Teachers	Middle School Bottom Teachers	High School Top Teachers	High School Bottom Teachers
>30	2	0	0	0
26-30	0	0	0	0
21-25	1	1	0	0
16-20	1	1	3	1
11-15	1	1	2	2
4-10	3	5	4	6

Notes: Blue represents more than 20 years of experience.
Green represents 20 or less years of experience.

Survey Results – Teacher Planning

In addition to asking about experience levels, the survey also asked teachers about how they plan for instruction. Five of eight top teachers and seven of eight bottom teachers reported that they had shared planning time with colleagues. In the high school study, which was conducted before the WCPSS districtwide implementation of professional learning communities (PLCs), eight out of nine top teachers reported shared planning, but six of nine bottom teachers planned alone. Top and bottom middle school teachers agreed that the main use of the shared planning time was for lesson planning. Five of eight top teachers marked lesson planning as the top use of time and two more top teachers chose lesson planning second. Seven of eight bottom teachers chose lesson planning first.

The high school teachers had marked pacing as their top use of shared planning time. Since all but one middle school teacher reported using most to all of the WCPSS Instructional Calendar, it was concluded that middle school teachers used the pace set by the calendar. There was less concern about how to remediate prerequisites with the well-prepared middle school algebra students. High school teachers spent much planning time organizing the curriculum into chunks that would remediate within new material. The top high school teachers reported using a spiraling method of delivery (Haynie, 2008).

Middle school teachers, on the other hand, presented material with a more linear approach that spent little time on remediating prerequisites. When asked to rank the importance of Algebra I topics defined by the names of chapters in an Algebra I book, top middle school teachers ranked the "basics of algebra" last of 14 topics and bottom teachers ranked the basics 10^{th}. Top high school teachers had ranked the basics third and the bottom high school teachers second. Besides the "basics", top middle school teachers found the task of ranking the topics to be a difficult one. Two top teachers stated that all topics were of equal importance. Using the average rankings, 7 of 14 topics were ranked in the top five in importance. Since several of the topics from the algebra book are not in the state curriculum, it can be concluded that middle school algebra teachers spend time on topics not in the state curriculum.

The top middle school teachers ranked "solving equations" first as did top and bottom high school teachers. Bottom middle school teachers ranked it third overall. A topic of disagreement was the importance of "linear regression", a topic that is in the state curriculum. Top high school teachers ranked it as sixth in importance, but top middle school teachers ranked it twelfth, bottom middle school teachers thirteenth as did bottom high school teachers. See Appendix B for details of topic rankings.

In planning, there were more differences between middle school teachers and high school teachers than between top and bottom middle school teachers. Middle school teachers used planning time to create lesson plans that progressed in a linear fashion throughout the curriculum. Top high school teachers spent planning time developing the pacing necessary to deliver a spiraling curriculum (Haynie, 2008). The main difference between top and bottom middle school teachers was the importance placed on the basics. Top middle school teachers ranked this topic last, while bottom middle school teachers ranked four other topics below the basics.

Survey Results – Instructional Delivery

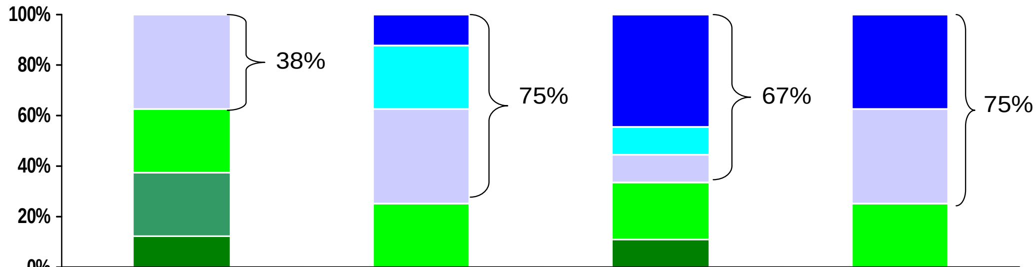
The survey also asked teachers to divide their instruction into the following eight instructional delivery methods by giving the percentage of the total instructional time spent on each activity:

- lecture,
- whole group discussion,
- projects,
- small groups,
- technology,
- testing, labs, or
- other.

There were three delivery methods where differences were noted between top and bottom middle school teachers. The methods were lecture, whole group discussion, and small groups.

Top middle school teachers reported using lecture 0% - 30% of their class time, while bottom middle school teachers reported using lecture 25%-50% of the time. The median amount of time for top teachers was 22.5%, but 30% for bottom teachers. Thirty-eight percent of top middle school teachers reported using lecture at least 30% of the time compared to 75% of the bottom middle school teachers. In the high school Algebra I study (Haynie, 2008), high school bottom teachers also had a median of 30%, but high school top teachers reported the highest lecture use with a median of 40% (Figure 10).

Figure 10
Percentage of Instructional Time Used in Lecture

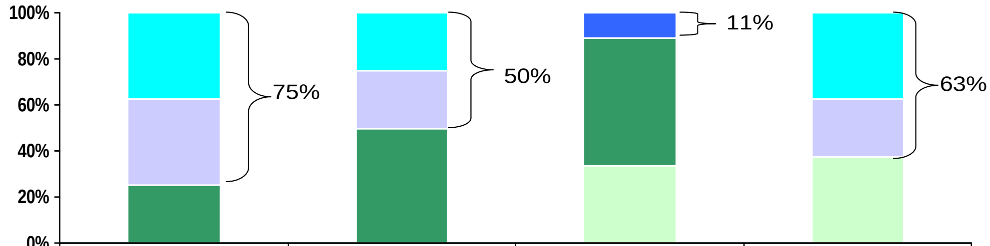


	Middle School Top Teachers	Middle School Bottom Teachers	High School Top Teachers	High School Bottom Teachers
>= 50%	0	1	4	3
40%-49%	0	2	1	0
30%-39%	3	3	1	3
20% - 29%	2	2	2	2
10% - 19%	2	0	0	0
0% - 9 %	1	0	1	0

Notes: Blue represents 30% or more of instructional time.
Green represents less than 30% of instructional time.

The use of whole-group discussion and small groups was also reported higher by top teachers than bottom teachers in middle school. Whole-group discussion had the same range of 10% to 35% for both groups, but the median was 25% for top teachers and 17.5% for bottom teachers. Seventy-five percent of top middle school teachers reported using whole group discussion at least 20% of the time compared to 50% of the bottom middle school teachers. The range for top teachers' use of small groups was 10% to 75% with a median of 20%, while the range for bottom teachers was 10% to 25% with a median of 15%. Sixty-three percent of top middle school teachers reported using small groups at least 20% of the time compared to 38% of the bottom middle school teachers. The medians for the teachers in the high school study (Haynie, 2008) for whole-group discussion were 10% (top teachers) and 20% (bottom teachers). For small groups it was 15% for top teachers and 7.25% for bottom teachers (Figures 11 and 12).

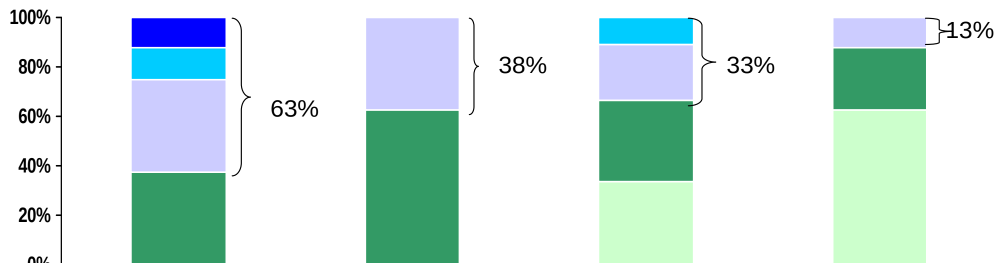
Figure 11
Percentage of Instructional Time Used in Whole-Group Discussion



	Middle School Top Teachers	Middle School Bottom Teachers	High School Top Teachers	High School Bottom Teachers
>= 50%	0	0	1	0
40%-49%	0	0	0	0
30%-39%	3	2	0	3
20% - 29%	3	2	0	2
10% - 19%	2	4	5	0
0% - 9 %	0	0	3	3

Notes: Blue represents 20% or more of instructional time.
Green represents less than 20% of instructional time.

Figure 12
Percentage of Instructional Time Used in Small Groups



	Middle School Top Teachers	Middle School Bottom Teachers	High School Top Teachers	High School Bottom Teachers
>= 50%	1	0	0	0
40%-49%	0	0	0	0
30%-39%	1	0	1	0
20% - 29%	3	3	2	1
10% - 19%	3	5	3	2
0% - 9 %	0	0	3	5

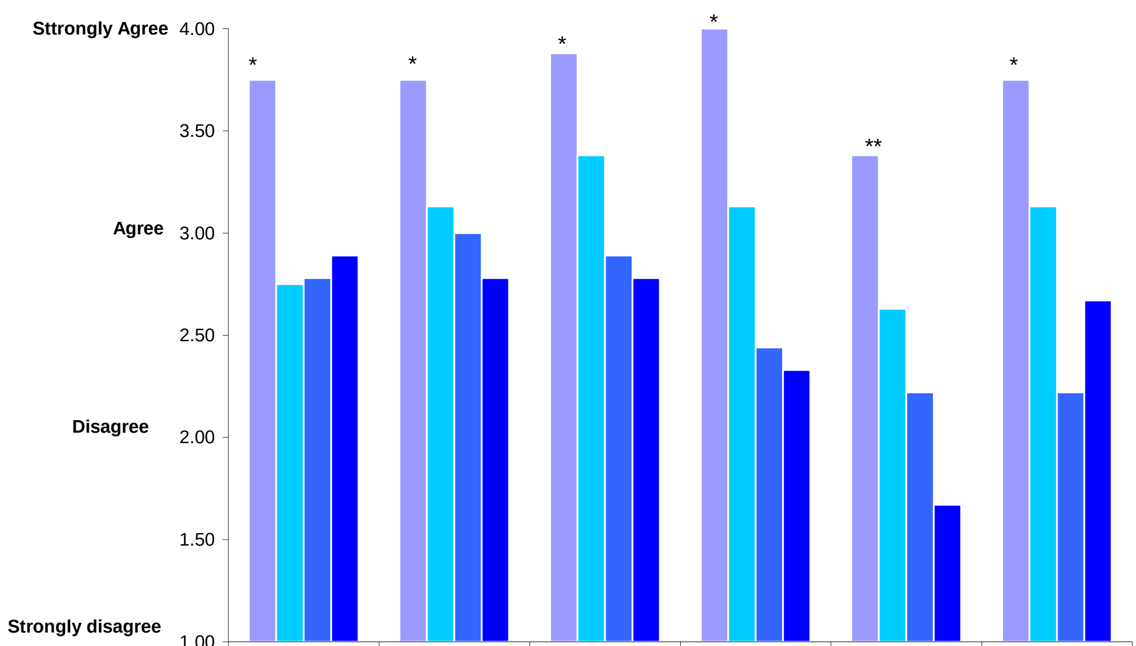
Notes: Blue represents 20% or more of instructional time.
Green represents less than 20% of instructional time.

Interestingly, reported use of projects was very uneven. Middle school teachers T1 and B8 reported spending 20% of their time on projects while no other teacher spent more than 5% of the time on projects, and nine reported no time on projects. Teachers T1, T5, B5, and B7 reported 10% to15% of time on labs. Five top and three bottom teachers reported no time in labs. The time spent on testing per week varied from 2 to 20 minutes, with an overall average of 13 minutes. The results for the high school study were similar (Haynie, 2008). There were no noted differences between groups of teachers on these three instructional delivery methods. See Appendix C for details by teacher.

Survey Results – Attitude Toward Students

Both the high school and middle school teacher surveys contained Likert scale statements that measured teacher attitude toward students. The responses were converted to a one to four scale from one for "strongly disagree" to four for "strongly agree". A test of significance found that the middle school top teachers' mean responses compared to middle school bottom teachers' mean responses were all significantly higher (showing stronger agreement) for every statement but one. All of the top teacher means were above a 3.0, ranging from 3.38 to 4.00. The bottom teacher means ranged from 2.63 to 3.38, with two means below a 3.0. The two areas with means below a 3.0 were for the statements that "my students have strong prerequisite skills" and "my students work hard" (Figure 13).

Figure 13
Mean Response to Attitude Toward Student Statements



	My students work hard	My students do their homework	My students seek extra help	My students set high standards	My students have strong prerequisite skills	My students seek to understand concepts
Top Middle School Teachers	3.75	3.75	3.88	4.00	3.38	3.75
Bottom Middle School Teachers	2.75	3.13	3.38	3.13	2.63	3.13
Top High School Teachers	2.78	3.00	2.89	2.44	2.22	2.22
Bottom High School Teachers	2.89	2.78	2.78	2.33	1.67	2.67

* significantly higher than all other teacher subgroups
** significantly higher than high school teacher subgroups

In looking at these results compared to those of the high school study (Haynie, 2008), it is also of interest to observe that the bottom middle school teachers' attitude means were only significantly higher than two means of the top high school teachers ("My students set high standards" and "My students seek to understand concepts", and two means of the bottom high school teachers ("My students set high standards" and "My students have strong prerequisite skills"). Top middle school teacher means were significantly higher than all high school teacher means. See Appendix D for detail by teacher and p-values.

Observation Results

Classroom observations were made of all 16 top and bottom teachers. Thirteen were observed by both the Evaluation and Research Administrator and a Curriculum and Instruction Administrator. Of particular interest were the behaviors observed in most to all top teachers. It is also of interest that these behaviors were also observed in most top high school teachers, but they were observed in fewer of the bottom middle school and bottom high school teachers. Although bottom teachers exhibited some of these positive behaviors, they were not as pervasive or consistent. That is, there was more of a complete "package" in top teachers. Table 10 summarizes these observations.

Table 10
Top Middle School Teacher Behaviors

Behavior	Middle School Top Teachers	Middle School Bottom Teachers	High School Top Teachers	High School Bottom Teachers
High expectations for **all** students	8 out of 8	1 out of 8	6 out of 6	3 out of 5
Mathematics vocabulary appropriately used by teachers and students	8 out of 8	1 out of 8	6 out of 6	5 out of 5
Teach bell to bell using an invigorated pace	8 out of 8	2 out of 8	4 out of 6	1 out of 5
Structured classroom management style with mutual respect	8 out of 8	4 out of 8	6 out of 6	2 out of 5
Classroom culture in which students were free to ask questions, contribute,and offer explanations	8 out of 8	5 out of 8	6 out of 6	0 out of 5
Sustained feedback	8 out of 8	5 out of 8	6 out of 6	0 out of 5
Probing Questions	7 out of 8	3 out of 8	6 out of 6	2 out of 5
Instruction adjusted appropriately based on student needs at the given moment	7 out of 8	4 out of 8	6 out of 6	3 out of 5
Good concept development (not individual pieces of information)	7 out of 8	6 out of 8	4 out of 6	0 out of 5
Variety of activities and frequent tansitions	6 out of 8	6 out of 8	6 out of 6	2 out of 5

Behavior Examples

High Expectations for All Students

Observing all students on task all of the class period in tasks that were rigorous and challenging was taken as an indicator of high expectations for all students. One top teacher challenged the class to use their own mental mathematics thinking by saying, "You're not going to make me write all the steps." Another teacher was heard to say, "I'm being mean making you spell math terms, right?" Teacher T1, who had 36% African-American/Black or Hispanic/Latino students, expressed amazement that other teachers had so little minority representation in classes. This teacher was observed including all students equally in class.

There was anecdotal evidence of mixed expectations of students in seven of eight bottom teachers' classes. Some students were allowed to be off task. Some were observed reading other books, having their heads down on desks, talking off-task, and obviously day-dreaming. One bottom teacher expressed annoyance toward a student's question. On asking for volunteers to do an exercise, this same teacher ignored this student's offer to do the exercise. Some teachers were observed giving praise to some students, but not to others. In another class, a student was retesting during class time, thus missing the current lesson. A bottom teacher, annoyed by off-task questions by one student, answered the question, "Why do we have to take Geometry?" by replying, " then suffer through it and never take Geometry again." The question was off task, but the shut-up answer set very low standards for the students. It validated the opinion that mathematics is a dreaded required course for many students.

Mathematics Vocabulary

The vocabulary used by top teachers and their students was appropriate for mathematical discussions. Top teachers had students study definitions of terms. One teacher had a word wall prominently displayed in the classroom. Top teachers pointed out the assumptions of properties and the restrictions on operations. Students were required to understand terms such as integer, radical, nonnegative, etc. to be able to use assumptions and restrictions. Top teachers had students read their math book, which led to use of proper terms in classroom discussions such as "leading coefficient", "maximum and minimum of a quadratic function", "denominator", "exponent', "base" , and "radical sign".

Inappropriate use of vocabulary was observed in seven of the eight bottom teachers' classes. Exercises were given with no instructions. Algorithms were used with no discussion of terms involved. Non-mathematical language was used instead of proper terms. Teachers were heard to say "flip", "plug-in", "send over", "bottom", and "over" exclusively instead of "use reciprocal", "substitute", "subtract from both sides", "denominator", and "divided by". Mathematical terms were also used incorrectly. One bottom teacher was heard saying, "Is the negative in (-b/2a) for the b or the whole equation?" (-b/2a is an expression not an equation). In another class, a student was heard to ask, "How do I solve ((6x+3)/3)?" He should have used simplify. This was a missed opportunity for vocabulary instruction that pointed out the difference between an expression and an equation. A particularly bad misuse of language was recorded during the observation of teacher B1, who said, "There is an equation that we can use to come up with the axis of symmetry point" and "the minimum is the axis of symmetry." In reality, the axis of symmetry is a line, not a point, and the minimum of a parabola is the y-value of the vertex.

Classroom Culture

Top teachers in middle school and high school had a classroom culture in which students were free to ask questions, contribute, or offer explanations**.** Observers recorded examples of inquiry, wrong answers, personal challenge, collaboration, and disequilibrium. In one class, there were two volunteers for the same problem, and each was asked to put the solution on the board *for comparison*. Students seemed quite comfortable doing this. They were willing to take the risk of being wrong, but also knew that there might be two ways to get the right answer. In accepting a student's answer, a teacher said, "That's right. Usually I add the 4 and 8 and then subtract the 7 but you can add in any order that you like." In another class, the teacher said, "Your group is the only one that made a chart. Will you go up and explain it?" The student responded, "Sure. For our formula, we looked at the second difference…"

Activities in top teacher classes centered on mathematical understanding, invention, and sense-making. Three supporting teacher quotes were heard:
- "Why do we assume that the variables all represent nonnegative numbers under the radicals?" (note: all the radicals were square roots).
- "Very good! I'm so glad that I asked you since I never thought of it that way."
- "What are the restrictions on these rational expressions? Be sure to list them first."

Observations of bottom teachers provided, on the other hand, some examples of a less positive classroom culture. In one class the teacher's response to a student asking, "Why is it the vertical line test and not the horizontal?", was "Because it's the vertical line test". Student "why" questions were answered with statement such as, "This is the way its done, remember your properties, and the steps." In another class, an open-ended question was accepted with only one answer, and a student who wanted to offer another solution was turned away.

Structured Classroom Management

In top teachers' classes, there were organized classroom routines. Students clearly understood their roles. All class time was used on worthwhile mathematical tasks that kept all students engaged. An invigorated pace was used with tightly organized lessons/activities that were broken into manageable sections. There were clearly stated daily objectives.

Within this structure, teachers were able to capitalize on unexpected learning opportunities and adjust instruction appropriately to meet student needs. Teachers listened carefully and used formative assessments regularly. In one of the observations of teacher T1, the lesson for the day was put aside while more work was done on the homework task because many students had questions. On the other hand, one of the bottom teachers was observed repeating an entire lesson as the student who asked a question was saying, "I only wanted one example", and the other students were restless and inattentive.

One top teacher taught students to be mathematicians using a repetitive instructional exploration rubric with each new topic. This teacher also explained upcoming test grading rubrics as quizzes were marked by students in class, thus enabling students to take ownership of their learning.

Sustained Feedback

Top teachers were persistent in giving, revisiting, and adjusting feedback to students. One teacher said, "I went back and did some problems at home last night and the slide method does not always work, let me show you". Other quotations were recorded:

- "You've got some mistakes in there, try again".
- "I should see better things on the scientific notation than I saw on the homework".
- "I think what you meant to do was pull out the GCF. Will you come up and fix that?"
- "[student's name] had a good idea of building a smaller model and working with smaller numbers."

Probing Questions

Top teachers asked probing questions of students. Examples of some probing questions recorded during observations included the following:

- "What is another way we could solve this?"
- "How do we know she has the right solution?"
- "How many of you have a different approach? We would like to see it."
- "How many ways are there to approach these problems?"
- "Which one of these explanations helped most?"

Focus Group Results

As in the focus groups of previous effectiveness studies, the main difference between the top and bottom groups was what each group emphasized in their discussions. The top teachers spent most focus group time discussing and sharing how they teach Algebra I. The bottom teachers spent much more time on the negatives of misplaced students. Their responses were more of the "poor me, what can I do" variety, while top teachers wanted to hear and share what they and their colleagues did.

Top teachers described their students as motivated, conscientious, going above and beyond, thirsting for learning, perfectionists, delightful, and fun to teach. Top teachers concluded that middle school Algebra I is a challenging course that works well for students who should be there. Bottom teachers described their students as the sharpest, the brightest, good students, hard workers, but, not all are motivated. They said that some students are not willing to dig and do work on new topics. They also said that some students are placed in Algebra I by a parent regardless of whether the teachers think the child is ready and "drag down" the class.

CONCLUSIONS

The main goals of this research study were to collect system-specific data to help teachers and district leadership understand current middle school Algebra I practices, identify and share best instructional practices in middle school Algebra I, continue to build a series of studies that identify the role of teachers, and other system staff/departments in the school improvement process, and identify the practices of effective improvement.

In 2007-08, 28 WCPSS middle schools offered Algebra I and 97% of these students scored proficient on the Algebra I EOC at the end of the course. The 29% of Algebra I students that take algebra before high school are among the strongest students in the district, yet only 79% scored at Level IV. The percentage of middle schools that made expected growth with their Algebra I students was 79%, with 68% making high growth. Despite high proficiency rates, there is ample room for improvement in student performance of middle school Algebra I students.

The average teacher residual scores, utilized to form the top and bottom groups for this study, identified teachers who could be used to document best instructional practices in middle school Algebra I. The results indicated that there was a qualitative difference between the performances of students in top versus bottom teacher classes. The difference in the average 7th grade mathematics scale scores of those two groups was negligible, but the difference in Algebra I EOC scale scores at the end of the course was not.

During focus-group interviews, the teachers stated that student success in high school mathematics was another indicator of teacher success in middle school Algebra I. They said that taking calculus in high school was the goal of most middle school algebra students. This statement and the difference in the quality of the results between top and bottom middle school teachers led to the question if there is a difference in the course-taking patterns of the top and bottom teachers. In order to begin to explore this question, a follow-up cohort study analyzed the high school mathematics course-taking patterns of students of the top and bottom teacher of this study. It found that for these two teachers and this cohort of students, there was a difference in course selection and the percentage of students who studied mathematics at the highest level. Sixty-nine percent of top teacher T1's students took the AP Calculus or higher courses in 12th grade compared to only 19% of bottom teacher B1's students. It needs to be noted that there are many possible intervening factors that would add to the explanation of the results, and additional study is recommended (Haynie, 2009).

All middle school Algebra I teachers had a positive attitude overall toward their students and their teaching assignment; yet top middle school teachers were significantly more positive than bottom middle school teachers. Bottom teachers were distracted by the students who were misplaced and lacked the math prerequisites or the study skills necessary for highest performance. Top teachers focused on the positive qualities of each student, expecting all students to rise to their high expectations.

NCTM's (2000) *Principles and Standards for School Mathematics* sets the teaching standards that all mathematics teachers K-12 should strive to hold in their classrooms. The top teachers in this study exemplified many of these standards in their practice. Top teachers used open-ended questions and explorations. There appeared to be no fear of what students might offer as answers. It was acceptable for students to be "smarter" and "quicker" in math than the teacher. Top teachers were confident in the role of facilitator and also shared in the class as a participant in learning. Topics were developed using organized, repetitive, and clear concept development. Concept development was achieved by using probing questions and sustained feedback. These findings were consistent with the NCTM stance: "Without connections students must learn and remember too many isolated concepts and skills" (NCTM, 2000, p.275), and "Teachers should help students recognize that all mathematics can and should be understood" (NCTM, 2000, p.125).

Top teachers used a variety of instructional methods. There was less lecture and more use of whole group discussion and small groups than in bottom teacher classes. Overall there was more student ownership of their learning. Top teachers used structured classroom management that provided students with clear definitions of their roles. Top teachers were observed adjusting their instruction appropriately by using frequent formative assessment. These findings also echo the NCTM stance: "Teachers can understand students' thinking when they listen carefully to students' explanations" (NCTM, 2000, p.126).

Top teachers assumed knowledge of basic algebraic skills and taught an enrichment-filled course at an invigorated pace. Students were exposed to both curriculum and beyond-curriculum topics. Precise mathematical vocabulary was expected and modeled by the teacher and all students, which again dovetails with the NCTM principals and standards: "Teachers should model appropriate conventional vocabulary" (NCTM, 2000, p.131). "Students are expected to learn serious, substantive mathematics with an emphasis on thoughtful engagement and meaningful language" (NCTM, 2000, p.213).

DISCUSSION AND IMPLICATIONS

Green (2005) in his book *Expectations: How Teacher Expectations Can Increase Student Achievement and Assist in Closing the Achievement Gap* discusses at length what research says about the correlation between teacher expectations and student achievement. The contrast between observations and the survey attitude items of the top and bottom middle school teachers of this study provided support in WCPSS of this research finding. Many educators and parents assume that middle school algebra students are the brightest and best. The top and bottom teachers of this study concurred; they were proud to teach such a high level course in middle school. Yet top teachers in this study held a significantly higher expectation for **all** their students than did the bottom teachers. During observations it was clear that students understood this expectation and had made it their own. The students of the top teachers fared better in terms of achievement during their year in Algebra I as measured by the EOC. A cohort study of high school mathematics course-taking patterns of students implied that they also rose to higher challenges later on in high school (Haynie, 2009).

The newly adopted WCPSS Board of Education (BOE) Goal is one that centers on high academic growth:

> *WCPSS students will demonstrate high academic growth; by 2014, all students will graduate on-time prepared to compete globally.*

In addition, the BOE has identified middle school leading indicators to be monitored in pursuit of that long-term goal. One of the indicators is to increase the enrollment and proficiency in Algebra I. As this study shows, proficiency in Algebra I is already very high, but it is less clear that the numbers of students should be increased. Proficiency in Algebra I can be reached without reaching the goal of high growth.

This study has identified behaviors that can be studied and adopted by all middle school teachers that will make improvements in their classroom instruction Yet attitude may be the most difficult to address in staff development activities. It is hoped that uncovering this difference will help to facilitate self-reflection that will lead to change. Middle school algebra teachers cannot rest on the high performance of their students as a group. They must also strive for the highest growth for all.

The following recommendations for improvement are made to all middle school Algebra I teachers:

- BELIEVE that **all** students will work and succeed at a very high level, and communicate that belief to all students.
- Study and use appropriate Algebra I vocabulary.
- Focus on concept development throughout topics and avoid isolated memory tricks.
- Listen carefully to students and give meaningful feedback in a positive way.
- Encourage all students to participate by having whole group discussions and small group experiences.
- Support a classroom culture that promotes open discourse between teacher and students.
- Study residual rosters.
- Study mathematics to increase depth of content knowledge.
- Reflect on growth data as well as performance data and instructional practice.

The following recommendations are made to school-based leadership:

- Support a school culture where **all** students can be successful (high expectations for all students).
- Support a school culture that promotes open discourse between school leadership and staff.
- Share results data with teachers including effectiveness rosters and indices.
- Use purposeful teacher course assignment.
- Reflect on growth data as well as performance data and instructional practice.

The following recommendations are made to district leadership:

- Make observations of most effective teachers that can be shared districtwide.
- Facilitate teacher reflection on teacher held beliefs and attitudes.
- Facilitate the study and appropriate use of Algebra I vocabulary.
- Help teachers focus on concept development throughout topics and avoid isolated memory tricks.
- Support a district culture where all students can be successful (high expectations for all students).
- Support a district culture that promotes open discourse between school leadership and staff.
- Support teacher improvement efforts.
- Provide data to teachers and schools on their effectiveness.
- Provide growth data as well as performance data to teachers.

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Appendix A

Educational Preparation and Teaching Experience Middle School Teachers

Teacher	School	Years Experience Teaching	Years Teaching Algebra	Years Teaching Middle School Algebra	Bachelors In Math or Math Education	Advanced Degree in Math or Education	Nationally Board Certified
T1	S4	24	21	21	n	n	n
T2	S9	28	7	7	y	n	y
T3	S12	10	4	4	n	n	n
T4	S5	26	11	8	n	n	y
T5	S2	16	4.5	4	y	n	n
T6	S6	34	30	30	y	y	n
T7	S7	36	36	13	y	y	n
T8	S13	33	19	19	y	y	y
B8	S11	10	8	8	y	n	n
B7	S14	37	24	22	n	n	y
B6	S10	23	8	8	n	n	n
B5	S1	22	17	9	y	y	n
B4	S1	14	6	6	y	n	y
B3	S10	11	11	11	y	n	n
B2	S3	7	4	4	y	n	n
B1	S8	19	9	7	y	y	n

Appendix B

Table B1
Median Ranking of Algebra Topics

	TOPIC	*MEDIAN MIDDLE SCHOOL TOP TEACHERS*	*MEDIAN MIDDLE SCHOOL BOTTOM TEACHERS*	*MEDIAN HIGH SCHOOL TOP TEACHERS*	*MEDIAN HIGH SCHOOL BOTTOM TEACHERS*	*Overall Median*
1	Basics of Algebra (order of operations,rules of exponents, properties operations with real numbers, etc.)	13.0	9.0	2.5	2.0	4.0
2	Solving equations	2.0	3.5	1.5	1.5	2.0
3	Solving inequalities	7.0	6.0	10.0	6.0	6.5
4	Solving and applying proportions	12.5	10.0	12.5	7.5	11.0
5	Graphing functions	6.0	4.0	4.5	4.5	5.0
6	Functions	5.5	3.0	5.0	5.5	5.0
7	Linear equations and their graphs	4.0	3.0	2.0	2.5	3.0
8	Systems of equations and inequalities	3.5	6.5	7.0	4.5	6.0
9	Exponents and exponential equations	9.0	8.0	8.5	9.5	9.0
10	Polynomials and factoring	6.0	7.0	7.0	6.5	7.0
11	Quadratic equations and functions	6.0	8.0	9.0	10.0	9.0
12	Radical expressions and equations	9.5	9.0	12.0	11.5	11.0
13	Rational expression and functions	11.5	13.0	13.0	13.0	13.0
14	Linear regression and data analysis	12.5	12.0	6.0	12.5	12.0

Table B2
Rankings of Algebra Topics

Topic Number	*TOPIC*	*RANK-MEDIAN MIDDLE SCHOOL TOP TEACHERS*	*RANK-MEDIAN MIDDLE SCHOOL BOTTOM TEACHERS*	*RANK-MEDIAN HIGH SCHOOL TOP TEACHERS*	*RANK-MEDIAN HIGH SCHOOL BOTTOM TEACHERS*	*RANK-Overall Median*
2	Solving equations	1	3	1	1	1
8	Systems of equations and inequalities	2	6	7	4	6
7	Linear equations and their graphs	3	1	2	3	2
6	Functions	4	1	5	6	4
5	Graphing functions	5	4	4	4	4
10	Polynomials and factoring	5	7	7	8	8
11	Quadratic equations and functions	5	8	10	11	9
3	Solving inequalities	8	5	11	7	7
9	Exponents and exponential equations	9	8	9	10	9
12	Radical expressions and equations	10	10	12	12	11
13	Rational expression and functions	11	14	14	14	14
4	Solving and applying proportions	12	12	13	9	11
14	Linear regression and data analysis	12	13	6	13	13
1	Basics of Algebra (order of operations,rules of exponents, properties operations with real numbers, etc.)	14	10	3	2	3

Appendix C
Percentage of Instructional Time by Delivery Method

Teacher	School	Lecture	Whole Group Discussion	Projects	Small Groups	Technology	Testing	Labs	Other
T1	S4	10	10	20	30	10	10	10	0
T2	S9	10	35	5	20	20	10	0	0
T3	S12	20	30	0	20	10	20	0	0
T4	S5	30	25	0	25	0	20	0	0
T5	S2	30	20	0	10	15	15	10	0
T6	S6	0	10	5	75	5	5	0	0
T7	S7	25	25	0	10	30	10	0	0
T8	S13	30	30	5	10	10	10	5	
B8	S11	25	10	20	20	10	15	0	0
B7	S14	50	15	0	15	5	5	10	0
B6	S10	45	10	0	15	10	20	0	0
B5	S1	25	15	0	15	15	15	15	0
B4	S1	30	35	1	20	10	2	2	0
B3	S10	40	20	0	10	10	20	0	0
B2	S3	30	25	0	25	5	10	5	0
B1	S8	30	30	5	10	35	20	5	0

Appendix D

Table D1
Teacher Attitude Responses

Teacher	School	My students work hard	My students do their homework	My students seek extra help	My students set high standards for success	My students have strong prerequisite skills	My students seek to understand the concepts of algebra
T1	S4	SA	SA	SA	SA	A	SA
T2	S9	SA	SA	SA	SA	SA	SA
T3	S12	SA	SA	SA	SA	A	SA
T4	S5	A	A	SA	SA	A	A
T5	S2	SA	SA	SA	SA	SA	SA
T6	S6	SA	A	SA	SA	SA	SA
T7	S7	SA	SA	A	SA	D	SA
T8	S13	A	SA	SA	SA	SA	A
B8	S11	A	SA	A	SA	D	A
B7	S14	A	SA	SA	A	A	A
B6	S10	A	A	A	A	A	A
B5	S1	A	A	A	A	A	A
B4	S1	A	A	SA	SA	SA	SA
B3	S10	A	A	SA	A	A	A
B2	S3	D	D	A	D	SD	A
B1	S8	D	A	A	A	D	A

Table D2
p-values

2-sample t-test of difference

	Middle Top /Middle Bottom	Middle Top /High Top	Middle Bottom /High Top	Middle Bottom /High Bottom	High Top/ High Bottom
1. My students work hard	**	**			
2. My students do their homework	*	**			
3. My students seek extra help	*	**			
4. My students set high standards	**	**	*	*	
5. My students have strong prerequisite skills		**		*	*
6. My students seek to understand concepts	**	**	**		

* significant at the .05 level
** significant at the .01 level