ED 468 962 TM 034 450

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TITLE	Modeling School and District Effects in the Math Achievement of Delaware Students Measured by DSTP: A Preliminary Application of Hierarchical Linear Modeling in Accountability Study.
PUB DATE	2002-04-03
NOTE	19p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 1-5, 2002).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Achievement Tests; Elementary Education; *Elementary School Students; Estimation (Mathematics); *Mathematics Achievement; School Districts; Schools; Scores; State Programs; Test Results; Testing Programs
IDENTIFIERS	Delaware; *Delaware Student Testing Program; Hierarchical Linear Modeling; *School Effects; Variance (Statistical)

ABSTRACT

This study modeled school and district effects in the mathematics scores of the Delaware Student Testing Program (DSTP) using hierarchical linear modeling. Three-level hierarchical models were fitted to estimate school and district effects in the DSTP mathematics scores and to examine the school and district variance with variables assessing student characteristics entered as predictors at each level. Data were collected in 4 waves, of which 3 were available for analyses: (1) 8,061 third graders from 1998 from 66 schools and 15 districts; (2) 8,066 fifth graders in 43 schools and 15 districts who took the test in 2000; and (3) matched data from 6,872 of the same students who took the third grade test in 1998 and the fifth grade test in 2000. Hierarchical linear modeling showed that the proportions of the variance at the school and district levels in the total variance of the DSTP scores for 1998 and 2000 were very small. Different patterns in the composition of variance at the school and district levels were observed for grade 3 and grade 5 students. For grade 3, the variance is predominantly at the school level, while for grade 5, the variance is nearly equal between the school and district levels. Results of the analysis also indicate that, in addition to the racial, gender, and socioeconomic status gaps commonly found in studies of mathematics performance, students who changed their schools, on average, had lower performance than those who stayed in the same school between grade 3 and grade 5. Results indicate the differential effect of Delaware schools on their students' performance in mathematics on standardized tests, but the reasons for the differences are not known. (Contains 7 tables and 17 references.) (SLD)

Modeling School and District Effects in the Math Achievement of Delaware Students Measured by DSTP: A Preliminary Application of Hierarchical Linear Modeling in Accountability Study

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Paper presented at the Annual Meeting of the American Educational
Research Association (AERA), New Orleans, Louisiana
April 3, 2002

Modeling School and District Effects in the Math Achievement of Delaware Students Measured by DSTP: An Application of Hierarchical Linear Modeling in Accountability Study

Background

The term "school effects" is found throughout the educational literature. Numerous studies have been done to identify effective schools and factors associated with the success or failure of schools. It has been pointed out (Raudenbush & Willms, 1995) that "school effect" usually refers to the extent to which attending a particular school modifies a student's outcome. This conception underlies current policy initiatives that aim to hold individual schools accountable for their contributions to student learning. A similar conception can be applied to the educational policy that intends to hold accountable the units higher than schools, for example, school districts. The publication of the ranking of both schools and districts in Delaware based on their student performance in the Delaware Student Testing Program (DSTP) is one example of such an effort.

In 1996, Delaware initiated a statewide assessment of student learning in mathematics, reading, writing, science, and social studies, as a response to the standards movement that began in 1991 and the adoption of Content Standards for all major school subjects in 1995 (Woodruff, 2000). In 1997, the Delaware General Assembly passed legislation that made the DSTP the official measure of progress towards the Delaware content standards and the major measurement tool for the state's new accountability system for students, schools, and districts. The law also established a system of school accountability based on student performance on the DSTP that holds all schools accountable. Each year since 1998, students in grades 3, 5, 8, and 10 are tested in mathematics, reading, and writing. Science and social studies were added in the spring of 2000 for students in grades 8 and 11, and in the fall of 2000 for students in grades 4 and 6.

The capability of decomposing and modeling the variance in student achievement scores on the different levels of our school system is a vital condition for a sensible system of accountability. Our study used the DSTP math scores as an example and tried to answer the following questions: How much variability in the student math performance is among schools and among school districts? How much of the observed variance among schools and districts can be attributed to the individual student background characteristics? And how much of the variance can be attributed to other factors on the school and district levels?

Statistical Analysis of School Effects

Educational researchers are interested in comparing schools or school districts in terms of the achievement of their students. The popularity of public accountability system in education calls for fair and scientifically valid approaches to estimate the school and district effects. It is commonly held among researchers that characteristics of students may undermine the fairness of judging schools or districts on the same basis (Yen, Schafer, & Rahman, 1999). Student background information, such as prior achievement, ethnicity, and socioecnomic status (SES) should be adjusted, and such adjustments should be made at both student and school levels (Caldas & Bankston, 1997).

There have been numerous explorations on the appropriate methodologies to adjust the impact of student demographic variables when estimating school or district effects. One approach is to regress school mean achievement scores on school means of one or more background variables (for example, the average SES of the students in a school). Then the school effect is each school's residual from the regression. This approach may be adequate to the extent that there is minimum within-school variance (in other words, schools impact all their students in similar ways). In most cases, however, such an aggregation results in loss of information and biased estimations.

An approach more sophisticated than simple aggregation to higher units of analysis involves the aggregation of residuals from the student-level regression models and the use of average deviation to indicate school effects. This approach takes account of individual characteristics and has been adopted in some recent studies (for example, Felter & Carlson, 1985; Saka, 1984, Webster & Olson, 1988). The concern is the variation at school levels that actually exists. For example, the average student characteristics of a school may have an effect on student achievement above and beyond the effect of the individual student's characteristics. Such an effect reflects the school's resources and environment, which provides a common experience for its students. Misestimated standard errors may occur when such dependence among the students within the same school is not modeled (Bryk & Raudenbush, 1992).

According to Goldstein (1995, 1987), an analysis that explicitly models the structure in which students are grouped within schools has several advantages. First, it can produce statistically efficient estimates of regression coefficients. Second, by incorporating the clustering information, it can provide standard errors and significant tests generally more conservative than those by traditional regression analysis. Third, it makes it possible to explore the extent to which differences in average achievement difference between schools can be accounted for by organizational factors as wells as other characteristics of students, and the extent to which school differ for different kinds of students. Finally, it enables the relative ranking of individual schools for public accountability system after adjusting for students' intake achievement on top of other student level and school level characteristics.

Among the various models proposed for multilevel analysis, Hierarchical Linear Modeling (HLM), systematically introduced by Bryk and Raudenbush (Raudenbush & Bryk, 1986; Bryk & Raudenbush, 1992, 1988; Raudenbush & Willms, 1995), gains most popularity among educational researchers (Kreft & De Leeuw, 1998). HLM provides estimates of linear equations that explain outcomes for group members as a function of the characteristics of the group as well as the characteristics of the members. It is relatively easy to implement and interpret, and thus it has been called the "model of choice" and widely used to estimate school effects (Young, Reynolds, & Walberg, 1996; Yen, Schafer, & Rahman, 1999; Webster, Mendro, Orsak, & Weerasinghe, 1998; Morris, 1995) and school district effects (Hargrove & Mao, 1997).

Method

Our study modeled the school and district effects in the math scores of the Delaware Student Testing Program using Hierarchical Linear Modeling. Three-level hierarchical models were fitted to estimate school and district effects in the DSTP math scores, and to examine the school and district variance with variables assessing student characteristics entered as predictors at each level.

Data

Up to this date, four waves of DSTP data have been collected (1998, 1999, 2000, 2001), which include both students' test scores and key demographic information about the students. The data of the first three years are currently available for analyses. The release of the 2000 data provides the first chance to study a specific cohort, namely, the 3rd graders tested in 1998 and then tested again in 2000 as 5th graders.

The study used three data sets. The first set (grade 3 data) included the math scores of the grade 3 students who took the DSTP in 1998. There were 8061 students in 66 schools and 15 districts. The second data set (grade 5 data) included the math scores of the grade 5 students who took the DSTP in 2000. There were 8066 students in 43 schools and 15 districts. The third data set (called "matched data" in the rest of this paper) included pairs of scores of the same individuals who took the 3rd test in 1998 and the 5th grade test in 2000. In this data set, there were 6872 students nested in 43 schools and 15 districts.

Model Specifications and estimation procedures

Three-level linear regression models were applied to the three data sets described above. The dependent variable was the math standard based scores (SBS), reported on a scale that runs approximately from 150 to 800.

Variables of student background information were specified as independent variables at each level. These variables are listed in Table 1. At the student level, dummy variables were created to indicate race, gender, and special education status and whether the student was assigned to the Title I reading program. The Title I Reading was chosen as a proxy for the student's SES status because the data available do not contain direct assessment of the socioeconomic status of individual students. For the matched data set only, three more variables were added. Grade 3 math scores in 1998 were used as an estimate of the student's previous math achievement. It was also known from preliminary analyses that 72% of the students in the matched data set changed their schools and 13% changed districts before they moved up to grade 5. Two more dummy variables were thus created to indicate whether a student had made changes in his/her school or district registrations between grade 3 and grade 5.

The variables specified at the school level include the size of school in terms of the number of students, and the proportions of students in a school who were white, female, or identified as special education students. The school's average SES status was assessed by the percentage of students in that school who were eligible for free or reduced price lunch (information obtained from sources other than the DSTP data files). For the matched data alone, there was one more variable that indicated the proportion of students who had transferred into the school from other schools.

At the district level, the variables included the district size (the number of students), the proportions of students in a district who were white, who were identified as special education students, and who were eligible for free or reduced price lunch. Another variable was the proportion of the students in the district who were enrolled via school choice. For the matched data set, there was also one more variable indicating the proportion of students who had transferred from another district.

The models were estimated with hierarchical linear modeling (HLM 5). For each data set, the estimations started with an unconditional model (Model 0) to assess the initial proportion of the variance at each level. In the following equations, *i* stands for individual student, *j* for school, and *k* for district. Model 0 did not include any predictors at any level, and the equations were:

$$\text{Level 1: } \text{Math}_{ijk} = \pi_{0jk} + e_{ijk}$$
$$\text{Level 2: } \pi_{0jk} = \beta_{00k} + r_{0jk}$$
$$\text{Level 3: } \beta_{00k} = \gamma_{000} + \mu_{00k}$$

Where
Math_{ijk} is the math score for student i in school j and district k,
π_{0jk} is the expected math score for school j in district k,
e_{ijk} is the residual for student i in school j and district k,
β_{00k} is the expected math score for district k,
r_{0jk} is the residual for school j in district k,
γ_{000} is the grand mean or the average of all students,
and μ_{00k} is residual for district k.

The next step of estimation (Model 1) added the student level variables to the level 1 equation:

$$\text{Level 1: } \text{Math}_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{WHITE})_{ijk} + \ldots + e_{ijk}$$

where WHITE is a dummy variable specifying whether a student is minority. Other student level covariates are not shown in the equation above.

All regression coefficients other than the intercepts were constrained to be constant within schools and districts so the models on level 2 and level 3 were:

$$\text{Level 2: } \pi_{0jk} = \beta_{00k} + r_{0jk}$$
$$\pi_{1jk} = \beta_{10k}$$
$$\cdots\cdots$$
$$\text{Level 3: } \beta_{00k} = \gamma_{000} + \mu_{00k}$$
$$\beta_{10k} = \gamma_{100}$$
$$\cdots\cdots$$

At the third step (Model 2) the level 1 intercept (π_{0jk}, mean math achievement of school j in district k) was regressed on the school level variables and the level 1 equation remained the same.

$$\text{Level 2: } \pi_{0jk} = \beta_{00k} + \beta_{01k}(\text{S\_LUNCH})_{jk} + \ldots + r_{0jk}$$
$$\pi_{1jk} = \beta_{10k}$$
$$\cdots\cdots$$

Here S_LUNCH is the percentage of students eligible for free or reduced price lunch in a school. Again, other covariates on the school levels are not listed in the equation of π_{0jk}.

$$\text{Level 3: } \beta_{00k} = \gamma_{000} + \mu_{00k}$$
$$\beta_{01k} = \gamma_{010}$$
$$\cdots\cdots$$

At the fourth step (Model 3 or the full model), the level-two intercept (β_{00k}, mean math achievement of district k) was regressed on the district level variables, with the level 1 and level 2 equations unchanged.

$$\text{Level 3: } \beta_{00k} = \gamma_{000} + \gamma_{001}(\text{D\_CHOICE})_{k} + \ldots + \mu_{00k}$$
$$\beta_{01k} = \gamma_{010}$$
$$\cdots\cdots$$

where D_CHOICE is the percentage of school choice students in a district. The other covariates on the district level are omitted.

Indicators of school and district effects

The above-specified model falls into the category of multilevel models with random intercepts and fixed slopes (Bryk & Raudenbush, 1992). For the purpose of estimating school and district effects, the following three equations are of most interest:

$$\text{Level 1: Math}_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{WHITE})_{ijk} + \ldots + e_{ijk}$$
$$\text{Level 2: } \pi_{0jk} = \beta_{00k} + \beta_{01k}(\text{S\_LUNCH})_{jk} + \ldots + r_{0jk}$$
$$\text{Level 3: } \beta_{00k} = \gamma_{000} + \gamma_{001}(\text{D\_CHOICE})_{k} + \ldots + \mu_{00k}$$

In this study, school and district effects are defined as the unique effect for each school (r_{0jk}) or district (μ_{00k}) after controlling for the impact of the covariates on the three levels. In other words, they are the deviance of the school or district average performance from their expected performance.

Results

Table 2 displayed the estimated random effects of the unconditional model (Model 0) for all three data sets. The results show that, on the whole, the proportions of the among-school variance and the among-district variance in the total variance were small. In fact the variance among districts at grade 3 is trivial (0.8% of the total variance). The variances among school and among districts are more balanced in the grade 5 data and in the matched data. For the grade 5 data (not matched), the two proportions out of the total variance are identical (3.4%).

The estimated fixed and random effects of the series of estimations (Model 0 through Model 3) for the three data sets are displayed in Tables 3, 4, and 5.

For grade 3 and grade 5 data sets, the inclusion of individual student characteristic variables at the student level (see Model 1) reduced the within-school variance of math scores by 24.6% and by19.2% respetively. The between-school variances were also reduced by 32.1% at grade 3 and by 32.9% at grade 5. For the grade 5 data, the student level variables helped to reduce the district level variance by 11.9%. For the grade 3 data, however, they actually increased the district level variance.

For the matched data the student level variables, including the grade 3 math scores and the two variables about school and district changes, decreased the student level variance by over 65% and helped to reduce the variance on the school and the district levels by 28.9% and 67.3% respectively.

The school level predictors, when added to the model (see Model 2), did not further reduce the school level variance in the grade 3 data but they accounted for over 73% of variance at the district level that had been increased at the previous step of modeling. For the grade 5 data, the school level predictors reduced the among-school variance by another 42.5% but they slightly increased the variance at the district level. For the matched data set, the school level variables further reduced the among-school variance by 34.6% and also increase the among-district variance by 14.3%.

The final models with district level variables added in (Model 3) reduced the among-district variance to non-significance in all three data sets. These variables also slightly increased the among-school variance in both the grade 5 data set and the matched data set but not in the grade 3 data set.

The estimated fixed effects on each level are also showed in Tables 2, 3, and 4. On the student level the results showed strong impacts of individual race, gender, special education status, and SES (approximated by the Title I Reading status) on math achievement in favor of white, male, non special education students, as well as students with higher SES. These effects were consistent across the datasets and significant even after previous math achievement (grade 3 scores) had been accounted for in the matched data models. Previous math achievement, in its own right, was the most significant predictor of the outcome math scores ($\beta = 0.728, t = 83.025, p < 0.001$). At the same time, changing school and changing district both had negative impact on math achievement.

The effects of the school level predictors varied across the three datasets. For grade 3, only the school size and the percentage of students eligible for free/reduced price lunch had significant effects, both negative, on the DSTP math achievement. For both grade 5 and the matched data, the only significant variable on the school level was the percentage of female students that was negatively related with math achievement.

At the district level, district size had significant negative effect on the math achievement of grade 3 students. For the grade 5 data, both district size and the percentage of students eligible for free or reduced price lunch students had significant negative effects. However, the percentage of special education students had highly significant positive effect ($\beta = 3.103, t = 5.771, p < 0.001$) in the grade 5 data. The matched data also showed that this variable had a positive impact after all other variables were controlled for. Neither district size nor the percentage of school choice students was found to have significant effect on math achievement for the matched data.

A revised, more compact model was fitted to the matched grade 5 data. The results were shown in Table 6. According to this model, after their previous math scores were controlled for, students would have lower performance if they were minority, female, lower in SES, identified as special education students, or if they changed schools from grade 3 to grade 5. The same students would perform worse if they were from a school with higher proportion of female students or of students entitled to free or reduced price lunch. Counter-intuitively, they would actually perform better if their district had higher percentage of special education students or of students coming from another district. This last model had 15 estimated parameters versus the 24 parameters in the full model, and fitted the data equally well as the insignificant difference in the deviances between the two models indicated ($\Delta\chi^2 = 8.709, df = 9, p < 0.25$).

The school and district effects were estimated by calculating the residual terms on the school and the district levels for the revised model of the matched data. Table 7 lists the residuals at both school and district levels. As indicators of school and district effects of the grade 5 math scores, these residuals are ranked and the rankings (called Modeled Rank in the table) are displayed together with the rankings based on the average school and district math scores (called Raw Score Rank in the table). For some schools and districts, the discrepancies in the two rankings are huge (School #11, School #38, and District #14, for example). For others, the raw and modeled rankings are not far from each other. The correlation between the two rankings of schools is 0.7412, and the correlation between the two rankings of districts is 0.7393.

Discussion

The Delaware Student Testing Program (DSTP) is designed exclusively as an assessment of the academic achievement of Delaware's public school students, rather than a research project intended to account for all the variation in student performance. The current study was based on available information and it examined only the math scores of DSTP. Nevertheless, this study is the first to decompose the variance of DSTP performance at different levels – student, school, and district, and provides a potential alternative to the current accountability system in Delaware.

The results of the current study indicate the following:

First, hierarchical linear modeling showed the proportions of the variance at the school level and the district level in the total variance of the DSTP math scores (1998 and 2000) were very small (see Table 2). According to Bryk and Raudenbush (1992), the variability among schools was normally 10 to 30 percent in school effect studies. At this moment it is not clear what grade levels and what subject fields were modeled in those studies and to what extent the current findings were deviant from the norm.

Second, different patterns in the composition of variance at the school and district levels were observed for grade 3 and grade 5 students. For grade 3 the variance is predominantly at the school level, while for grade 5 the variance is nearly equal between the school level and the district level. The larger number of grade 3 schools (66 schools), and subsequently smaller number of students within each school, might have contributed to the larger among-school variation in the grade 3 math scores.

Third, besides the racial, gender, and SES gaps commonly found in studies of math performance, the results from the current analysis indicated that on average students who had changed their schools had lower performance than those who stayed in the same school between grade 3 and grade 5, after the impacts of other student background characteristics including their previous math achievement were controlled for. The study needs to be replicated for other subject areas and grade levels before any generalizations can be made. In Delaware, such an observation may indicate a problem caused by a lack of consistency in school experience when students *have to* leave a certain school to be in a higher grade.

Finally, while district level variability in math achievement could be easily explained away by one or two variables of student characteristics aggregated to that level, the variance at the school level remained significant even in the full model. In other words, the models we have specified are not exhaustive to account for the variance at the school level. From another perspective, it indicates the existence of differential effect of Delaware schools on their students' math performance in standardized testing, after the impacts of student background characteristics, including their previous achievement, were controlled for. The reasons for such a difference are not known from the current study.

In further analyses, we expect to expand and modify the study in the following ways. First, hierarchical linear modeling of DSTP scores will be extended to other subject areas, such as reading, writing, science, and social studies to explore the similarity and differences in school and district effects across these subjects. Public accountability systems usually ask for a composite value, rather than scores of a single subject, to stand for the relative efficiency of a school or a district. We need to explore the ways hierarchical linear models can be helpful in this aspect.

Second, hierarchical linear modeling will be applied to the DSTP scores of all the grades in every year since 1998. The aim is to reveal any general pattern or change in the school and district effects in the first four years of the DSTP program.

Third, more variables on the school level will be introduced to account for the part of variance that the student background characteristics alone cannot explain. It will help to answer an important question of what makes a school effective or ineffective after we take their students' characteristics into consideration.

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Table 1: List of Variables at Each Level

Name of Variable	Description of Variable
Student Level	
WHITE	Race of student, 1 for white (non-Hispanic), 0 for non-white
FEMALE	Gender of student, 1 for female, 0 for male
TI_READ	Student was entitled to Title-I Reading, 1 for yes, 0 for no
SPED	Student is special ed, 1 for yes, 0 for no
CH_SCH *	Student changed school, 1 for yes, 0 for no
CH_DIS *	Student changed district, 1 for yes, 0 for no
G3MATH *	DSTP math score of grade 3
School Level	
S_LUNCH	Percentage of students eligible for free/reduced price lunch in a school
SCH_SIZE	Number of students in a school
S_WHITE	Percentage of white students in a school
S_FEMALE	Percentage of female students in a school
S_SPED	Percentage of special ed students in a school
S_CHANGE *	Percentage of students from another school
District Level	
DIST_SIZE	Number of students in a district
D_WHITE	Percentage of white students in a district
D_SPED	Percentage of special ed students in a district
D_LUNCH	Percentage of students entitled to free or reduced price lunch in a district
D_CHOICE	Percentage of school choice students in a district
D_CHANGE *	Percentage of students from another district

* For the matched data only

Table 2: Variance components of the null models

	Variance Component	Proportion in Total Variance
Grade 3 (1998)		
Student Level	1508.845	
School Level	117.397 **	7.2%
District Level	14.233	0.8%
Grade 5 (2000)		
Student Level	1453.465	
School Level	54.003 **	3.4%
District Level	53.076 **	3.4%
Grade 5 (98-00 Matched)		
Student Level	1625.864	
School Level	65.816 **	3.8%
District Level	36.472 *	2.1%

** Coefficient significant at the 0.001 level

* Coefficient significant at the 0.01 level

Table 3: Estimated Effects of the Models for Grade 3 Math 1998

	Model 0	Model 1	Model 2	Model 3
Fixed effects				
Grand Mean	410.299	404.064	415.060	458.827
White Student		24.868 ***	24.775 ***	24.774 ***
Female Student		-2.286 **	-2.302 **	-2.302 **
Title I Reading Student		-26.462 ***	-26.712 ***	-26.712 ***
Special Education Student		-35.317 ***	-35.321 ***	-35.321 ***
School Size			-0.032 *	-0.032
% of Free Lunch Students in School			-0.274 *	-0.485 **
% White Students in School			-0.076	-0.089
% of Female Students in School			0.098	0.017
% of Special Ed Students in School			0.159	0.030
District Size				-0.001 *
% White Students in District				-0.480
% of Special Ed Students in District				0.859
% of Free Lunch Students in District				-0.031
% of School Choice Students in District				0.378
Random Effects				
Student Level Variance Component	1508.845	1137.640	1137.673	1137.746
School Level Variance Component	117.397 ***	80.874 ***	79.892 ***	68.073 ***
District Level Variance Component	14.233	31.886	8.343	0.123
Model Fit				
Deviance	82031.766	79756.908	79748.561	79735.031
Number of Estimated Parameters	4	8	14	19

*** Coefficient significant at the 0.001 level

** Coefficient significant at the 0.01 level

* Coefficient significant at the 0.05 level

Table 4: Estimated Effects of the Models for Grade 5 Math 2000

	Model 0	Model 1	Model 2	Model 3
Fixed effects				
Grand Mean	461.605	453.113	476.722	495.369
White Student		23.424 ***	23.343 ***	23.343 ***
Female Student		-1.945 *	-1.914 *	-1.914 *
Title I Reading Student		-31.722 ***	-31.954 ***	-31.954 ***
Special Education Student		-21.108 ***	-21.055 ***	-21.055 ***
School Size			0.008	-0.001
% of Free Lunch Students in School			-0.158	-0.181
% White Students in School			0.101	0.050
% of Female Students in School			-0.545 *	-0.474 *
% of Special Ed Students in School			-0.206	0.329
District Size				-0.001 *
% White Students in District				-0.409
% of Special Ed Students in District				3.103 ***
% of Free Lunch Students in District				-0.591 *
% of School Choice Students in District				0.161
Random Effects				
Student Level	1453.465	1174.597	1174.579	1174.398
School Level	54.003 ***	36.197 ***	20.785 ***	26.023 ***
District Level	53.076 ***	46.743 ***	47.267 ***	0.0218
Model Fit				
Deviance	81724.264	80001.778	79988.306	79970.415
Number of Estimated Parameters	4	8	14	19

*** Coefficient significant at the 0.001 level

** Coefficient significant at the 0.01 level

* Coefficient significant at the 0.05 level

Table 5: Estimated Effects of the Models for the Matched Grade 5 Math Scores (1998-2000)

	Model 0	Model 1	Model 2	Model 3
Fixed effects				
Grand Mean	458.396	458.245	502.641	506.196
Grade 3 Math		0.729 ***	0.728 ***	0.728 ***
White Student		7.981 ***	7.991 ***	8.001 ***
Female Student		-1.226 *	-1.192 *	-1.191 *
Title I Reading Student		-9.928 ***	-10.004 ***	-10.001 ***
Special Education Student		-12.723 ***	-12.722 ***	-12.727 ***
Change District		-1.574	-1.816	-1.802
Change School		-2.645 *	-1.996	-2.005
School Size			-0.003	-0.001
% of Free Lunch Students in School			-0.201	-0.174
% of White Students in School			-0.008	-0.036
% of Female Students in School			-0.625 *	-0.598 *
% of Special Ed Students in School			-0.282	-0.322
% of Students from Another School			-0.036	-0.047
District Size				-0.001
% White Students in District				-0.193
% of Special Ed Students in District				2.046 *
% of Free Lunch Students in District				-0.371
% of School Choice Students in District				-0.011
% of Students from Another District				0.124
Random Effects				
Student Level	1625.864	560.627	560.589	560.547
School Level	65.816 ***	46.748 ***	30.538 ***	35.046 ***
District Level	36.472 **	11.914 *	13.622 **	0.023
Model Fit				
Deviance	70403.909	63109.459	63096.064	63087.107
Number of Estimated Parameters	4	11	18	24

*** Coefficient significant at the 0.001 level

** Coefficient significant at the 0.01 level

* Coefficient significant at the 0.05 level

Table 6: Estimated Effects of a Revised Model for the Matched Grade 5 Math Scores (1998-2000)

	Revised Model
Fixed effects	
Grand Mean	483.614
Grade 3 Math	0.729 ***
White Student	8.040 ***
Female Student	-1.207 *
Title I Reading Student	-9.884 ***
Special Education Student	-12.723 ***
Change School	-3.328 **
% of Free Lunch Students in School	-0.283 **
% of Female Students in School	-0.681 **
% of Special Ed Students in District	1.579 *
% of Students from Another District	0.154 *
Random Effects	
Student Level	560.843
School Level	36.725 ***
District Level	0.011
Model Fit	
Deviance	63095.816
Number of Estimated Parameters	15

*** Coefficient significant at the 0.001 level

** Coefficient significant at the 0.01 level

* Coefficient significant at the 0.05 level

Table 7: Residuals at the School and the District Levels of the Revised Model for the Matched Data and Their Ranks as Compared with Ranks Based on Raw Scores (School and District Ids Are Fictional)

School ID	Residual	Modeled Rank	Raw Score Rank	District ID	Residual	Modeled Rank	Raw Score Rank
1	6.6141	3	4	1	-47.7275	5	4
2	15.7302	1	1	2	-57.6495	11	9
3	-13.3650	23	20	3	-54.7244	8	12
4	-16.1324	27	24	4	-57.3371	10	13
5	-6.3479	15	17	5	-42.1008	2	1
6	-5.1009	12	13	6	-49.3298	6	5
7	-12.1168	20	26	7	-60.3204	12	15
8	-11.5624	19	33	8	-49.8736	7	6
9	-6.2247	14	21	9	-33.7986	1	2
10	-14.5916	25	37	10	-54.9372	9	7
11	-0.2852	8	34	11	-70.5474	14	14
12	-6.6549	16	11	12	-77.1783	15	10
13	2.2857	6	8	13	-67.4617	13	8
14	14.4737	2	2	14	-46.7129	4	11
15	-4.9165	11	15	15	-43.9165	3	3
16	-12.6334	22	39				
17	-9.8537	18	16				
18	5.8865	4	7				
19	-6.7165	17	10				
20	-15.0903	26	27				
21	-12.2683	21	22				
22	-28.0128	36	28				
23	-34.7600	40	42				
24	-24.2142	33	36				
25	-31.1423	38	38				
26	-30.9586	37	35				
27	-20.3595	30	19				
28	-26.9961	34	18				
29	-20.8662	31	9				
30	-37.1977	41	40				
31	-44.9209	42	41				
32	-34.2223	39	32				
33	-47.4590	43	43				
34	-23.8881	32	23				
35	-27.0425	35	30				
36	-20.2022	29	12				
37	-19.4254	28	29				
38	-2.2008	9	31				
39	-14.1608	24	25				
40	4.3993	5	3				
41	-6.0434	13	14				
42	-2.3733	10	5				
43	1.7527	7	6				

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