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ABSTRACT

The purpose of this study was to examine the relationships between classroom instructional practices and computation and geometry achievement. Relationships between mathematics achievement and classroom characteristics were also explored. The sample of 1,032 students and their teachers (n=147) was selected from the 1992 Trial State Mathematics Assessment for Mississippi. The instruction-related variables included the frequent use of worksheets, small groups, and manipulatives. Additional variables included the frequent use of writing, real life problems, and assessment with problem sets. The measures of mathematics achievement used included the plausible value estimates for the numbers and operations and geometry subscales from the 1992 Trial State Mathematics Assessment. The use of hierarchical linear modeling revealed significant differences between African-American and white students in computation and geometry achievement as well as differences between male and female students in geometry. Four classroom characteristics were significantly associated with average geometry achievement. Frequent use of worksheets and assessment with problem sets were significantly associated with average computation achievement. The frequent use of writing was significantly associated with average geometry achievement. (Author)

The Effects of Instructional Practices on Computation and Geometry Achievement

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Abstract

The purpose of this study is to examine the relationships between classroom instructional practices and mathematics achievement. The sample of 147 teachers and 1,032 students was selected from the 1992 Trial State Mathematics Assessment for Mississippi. The instructional related variables used in this study include the frequent use of worksheets, small groups, and manipulatives. Additional variables include the frequent use of writing, real life problems, and assessment with problem sets. The measures of mathematics achievement used in this study include the plausible value estimates for the numbers and operations and geometry subscales from the 1992 Trial State Mathematics Assessment. The use of hierarchical linear modeling revealed significant differences between African-American and White students in computation and geometry achievement as well as differences between male and female students in geometry. The results show that four classroom characteristics were significantly associated with average geometry achievement. Finally, the results indicate that the frequent use of worksheets and assessment with problem sets were significantly associated with average computation achievement and the frequent use of writing was significantly associated with average geometry achievement.

The Effects of Instructional Practices on Computation and Geometry Achievement

This study is an extension of a research project being conducted by the Bureau of Educational Research and Evaluation at Mississippi State University (MSU). The project which was funded by the U. S. Department of Education is using 1992 NAEP Trial State Mathematics Assessment data for three southeastern states to examine the relationships between student achievement in mathematics and three sets of policy relevant variables. The project involves the use of hierarchical linear modeling to examine the relationships between student achievement and achievement differences based on student demographic variables and characteristics of schools and the instructional practices used in those schools.

The analyses conducted in the MSU project involved the aggregation of responses from student and teacher questionnaires to the school level in order to utilize weights that are provided for generalizability. This type of aggregation resulted in school variables such as the proportion of students who used worksheets weekly. Since these variables were continuous, the results of the analyses do not indicate differences in achievement resulting from the frequent or infrequent use of instructional practices. This study modifies the analysis conducted in the MSU project by treating classes as the second level of analysis; including variables related to the types of problems used in class, the extent to which writing was used in mathematics classes, and the use of assessment with problem sets; and focusing on two aspects of mathematical knowledge rather than composite mathematics achievement.

The purpose of this study is to examine possible relationships between student achievement and instructional practices used by eighth grade public school teachers in Mississippi. In addition to examining relationships with average classroom achievement, this study examines possible relationships between achievement differences related to demographic and background characteristics of the students and the type of mathematics instruction that was received by the students.

Sample

This study used data from the 1992 Trial State Mathematics Assessment for Mississippi. The original data contained achievement and demographic information on approximately 2,500 eighth grade public school students. In addition, the data contained information related to the instructional practices used by the teachers of the assessed students. The sample used in this study consisted of 147 teachers and 1,032 students. As shown in Table 1, the sample contained approximately equal numbers of students based on race and sex.

Insert Table 1 About Here

Dependent Variables

The dependent variables used for the student level analyses were the five plausible value estimates for the computation and geometry components of the Trial State Mathematics Assessment. The classroom level analyses utilized results obtained from the student level analyses as the dependent variables. For each classroom, these results included the average achievement of the students and the achievement differences between African-American and White students as well as male and female students.

Independent Variables

This study included four student variables, four classroom characteristic variables, and six variables related to the instructional practices of eighth grade public school teachers participating in the 1992 assessment. The student variables were recoded as shown in Table 2. Three of the student variables were recoded so that the coefficients could be interpreted as achievement differences. The race variable was recoded to include only African-American and White students while the sex variable was changed in numerical value only. The parent education variable was recoded to indicate whether or not at least one parent had received some post high school education. The final student variable, attitude toward mathematics, was constructed from six responses contained in the student questionnaire. In order to construct the variable, each of the six variables was dichotomized to indicate a positive or negative attitude. The final attitude variable was the mean of the six recoded variables and represented the proportion of questions to which a student indicated a positive attitude. After the variables were recoded and constructed, they were centered by subtracting the corresponding classroom mean. The centering allowed the intercept to be interpreted as the achievement of a student with average race, sex, parent education level, and attitude.

Insert Table 2 About Here

Three of the four classroom characteristic variables were created using the uncentered student level variables. These included the proportions of African-American students and students with at least one parent with some post-high school education as well as the average attitude toward mathematics of students taught by each teacher. The last classroom characteristic variable represented the ability of the class as perceived by the teacher. For this variable, the coding was reversed so that larger values represented higher ability. Like the student variables, the classroom characteristic variables were centered by subtracting the grand means in order to interpret the intercepts.

Each of the six instructional practice variables was recoded according to Table 3. The final instructional practice variables were dichotomized and represented the frequent or infrequent use of worksheets, small groups, manipulatives, and real life problems as well as writing about problem solving and assessing students with problem sets.

Insert Table 3 About Here

Analysis

This study utilized a series of two level hierarchical linear models to examine possible associations between classroom characteristics, instructional practices, and student achievement. Because NAEP uses a set of five plausible values, the analyses were conducting using the HLMPV statistical package. Furthermore, because NAEP does not provide appropriate weights for teachers in the sample, the current study did not use weights at the either level of analysis. Because the purpose of this study was to identify possible relationships, an alpha level of .10 was used for determining statistical significance.

The student or first level regression equations contained variables relating to the race, sex, and attitude toward mathematics for each student. These equations also included the variable that indicated the highest level of education for either of the student's parents. The inclusion of the dichotomized race and sex variables allowed for the explanation of the variation in the achievement differences using the teacher level equations.

Two types of classroom or second level equations were specified. The first type was the unconditioned model and contained only an intercept term. These models were used to determine the average of the student level coefficients and the amount of variation in the coefficients among the eighth grade classrooms before any classroom characteristics or instructional practices were included. The second type of model was the conditioned model and contained the intercept as well as the classroom characteristic or instructional practice variables. The effectiveness of each model in explaining the variation among classes was determined by comparing the variance components from the unconditioned and conditioned models.

Results

Unconditioned Models

Table 4 contains the average within-class parameter estimates for computation and geometry achievement based on the unconditioned model. The table illustrates that the average computational achievement was 255.06. Also, the race-ethnicity parameter estimate indicates that African-American students scored on average 19.80 points, $t = -7.07$, $p \leq .01$, below White students. Additionally, the parent education estimate indicates that students with at least one parent with some post-high school education averaged 7.17 points, $t = 3.24$, $p \leq .01$, higher than students whose parents did not have any post-high school education. Finally, the attitude parameter estimate indicates that a more positive attitude toward mathematics was associated with higher computation achievement, $t = 5.00$, $p \leq .01$.

Insert Table 4 About Here

The results of the unconditioned model in geometry are similar to those from the computation model. The results show that African-American students averaged 24.36 points, $t = -6.93$, $p \leq .01$, below White students and female students scored 6.32 points, $t = -2.86$, $p \leq .01$, below male students. The results also show that a positive relationship existed between student attitude toward mathematics and achievement in geometry, $t = 4.41$, $p \leq .01$. Finally, the unconditioned model indicates that students with at least one parent with some post-high school education outperformed students whose parents did not have any post-high school education by almost 6.5 points, $t = 2.78$, $p \leq .01$.

The averaged final estimates of the variance components associated with the student level parameter estimates are contained in Table 5. The table shows that only two of the variance components were statistically significantly different from zero for the computation and geometry models. In the computation model, the variance component associated with the intercept or average achievement was 403.94, $\chi^2(47) = 186.79$, $p \leq .01$. The second statistically significant variance component was associated with the race-ethnicity parameter, $\chi^2(47) = 30.57$, $p \leq .05$.

Insert Table 5 About Here

In the geometry model, the variance components associated with the intercept and race-ethnicity parameters were significantly different from zero. The intercept variance component was 446.24, $\chi^2(47) = 184.60$, $p \leq .01$. The variance component associated with the race-ethnicity parameter was 37.81, $\chi^2(47) = 30.37$, $p \leq .05$. Based on the results of the chi-square tests on the variance components, classroom characteristic and instructional practice models were constructed for the intercept and race-ethnicity parameters.

Classroom characteristic models

The results of the classroom characteristic models for the average computation and geometry achievement are presented in Table 6. The results for computation achievement show that there was a statistically significant positive association for the attitude of the class toward mathematics, $t = 3.41$, $p \leq .01$, the proportion of students with at least one parent receiving some post-high school education, $t = 3.04$, $p \leq .01$, and the teacher's perceived ability of the class,

$t = 2.74$, $p \leq .01$. The results also show that there was a statistically significant negative association for the proportion of African-American students in a class, $t = -9.11$, $p \leq .01$. Table 6 illustrates that the parameter variance that remained after the classroom characteristic model was statistically significantly different from zero, $\chi^2(43) = 127.57$, $p \leq .01$, and the classroom characteristic model explained 72% of the parameter variance that remained after the unconditioned model.

Insert Table 6 About Here

The results of the classroom characteristic model for average geometry achievement indicate that a statistically significant positive association existed for the attitude of the class toward mathematics, $t = 3.95$, $p \leq .01$. They also show that there was a statistically significant negative association for the proportion of African-American students in a class, $t = -9.02$, $p \leq .01$. Table 6 shows that the remaining parameter variance associated with the intercept parameter was statistically significantly different from zero, $\chi^2(43) = 106.46$, $p \leq .01$, and the classroom characteristic model explained 76% of the parameter variance that remained after the unconditioned model.

Table 7 contains the results of the classroom characteristic models for the race-ethnicity parameter for computation and geometry achievement. The results for the computation model show that the proportion of African-American students in a class was statistically significantly associated with the race-ethnicity parameter, $t = -2.10$, $p \leq .05$. Table 7 also shows that the remaining parameter variance was statistically significantly different from zero, $\chi^2(43) = 29.97$, $p \leq .10$. Additionally, the classroom characteristic model explained 57% of the parameter variance that remained after the unconditioned model.

Insert Table 7 About Here

The results for the classroom characteristic model in geometry show a statistically significant association for the proportion of African-American students in a class, $t = -1.99$, $p \leq .05$. Table 7 also indicates that the remaining parameter variance was 30.93, $\chi^2(43) = 31.43$, $p \leq .10$. Finally, the classroom characteristic model explained 18% of the parameter variance that remained from the unconditioned model.

Instructional practice models

The results of the instructional practice model for average achievement in computation and geometry are presented in Table 8. The results show that there was a statistically significant positive association for frequent assessment with problem sets, $t = 2.40$, $p \leq .05$. There was also a statistically significant negative association for frequent use of worksheets, $t = -1.64$, $p \leq .10$. Table 8 shows that the remaining parameter variance was significantly different from zero, $\chi^2(41) = 204.37$, $p \leq .01$, and the instructional practice model explained 13% of the parameter variance that remained from the unconditioned model.

Insert Table 8 About Here

The instructional practice model for average achievement in geometry produced one statistically significant predictor. The results show that there was a negative association between frequent writing and average geometry achievement, $t = -1.79$, $p \leq .10$. The results also show that the remaining parameter variance was statistically significantly different from zero, $\chi^2(41) = 216.27$, $p \leq .01$, and the instructional practice model explained 11% of the variance that remained after the unconditioned model.

The results of the instructional practice models for the race-ethnicity parameter for computation and geometry are presented in Table 9. The results show that there were no statistically significant associations between the instructional practice predictors and the race-ethnicity parameter for computation or geometry. The results also show that the instructional practice model for computation explained 8% of the parameter variance that remained after the unconditioned model and the remaining parameter variance was statistically significantly different from zero, $\chi^2(41) = 29.42$, $p \leq .10$. For geometry, the instructional practice model did not explain any of the parameter variance that remained from the unconditioned model, and the remaining parameter variance was not statistically significantly different from zero, $\chi^2(41) = 32.99$, $p > .10$.

Insert Table 9 About Here

Summary

This study used data from the 1992 Trial State Mathematics Assessment for Mississippi to explore possible relationships between computation and geometry scores and instructional practices used by eighth grade mathematics teachers. In addition, relationships between mathematics achievement and classroom characteristics were explored. Through the use of hierarchical linear modeling, relationships were identified for average computation and geometry scores and achievement differences between African-American and White students.

The results of the analyses indicated that classes with higher proportions of students with at least one parent having some post-high school education and higher ability as perceived by the teacher were associated with higher computation scores. Furthermore, classes with more positive attitudes toward mathematics were associated with higher computation and geometry scores. However, classes with larger proportions of African-American students were associated with lower computation and geometry scores.

The instructional practices model for average computation and geometry achievement revealed two significant relationships with computation and one with geometry. The results showed that classes who were frequently assessed with problem sets had higher computation scores and classes who used worksheets frequently had lower computation scores. They also indicated that classes who wrote frequently were associated with lower geometry scores.

The classroom characteristics and instructional practices models for achievement differences between African-American and White students revealed only one significant relationship. These results indicated that classes with higher proportions of African-American students were associated with larger differences in both computation and geometry scores.

Before making recommendations, the following limitations should be considered. First, this study was correlational and, therefore, did not establish the cause and effect that would be desired in order to stimulate changes in the delivery of mathematics to eighth grade students in Mississippi. Second, classrooms were used as the second level of analysis. The data that was used for this study did not contain a random sample of teachers nor were students randomly selected within teachers. Furthermore, the lack of weights at the classroom level could have affected the results of the statistical tests. Finally, many of the variables in this study were based on recommendations contained in the Professional Standards for Teaching Mathematics (NCTM, 1992) which was designed to provide a framework for teaching the content of the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989). Since this data was collected in Spring 1992, it is likely that the curriculum being taught in schools was not the same as the curriculum outlined in NCTM's 1989 publication.

Although this study did not have the ability to directly influence changes in the delivery of mathematics, it can provide recommendations for further research. First, the ability of classroom characteristics to explain a large portion of the variation in achievement should be considered in future analyses. Examining the relationships between instructional practices and achievement after the variation due to these characteristics has been accounted for through the use of covariates or by conducting separate analyses would provide additional information on the effects of instructional practices. Second, because the Trial State Mathematics Assessment is only administered every four years, attempts should be made to utilize existing state testing programs to collect data similar to that collected in the Trial State Mathematics Assessment. This would provide additional advantages such as removing the need for weights since the population of students would be used and avoiding the use of plausible value estimates for measuring achievement. Finally, additional research should attempt to explain the relationships identified in this study and determine the direction of possible cause and effect relationships.

References

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (1992). Professional standards for teaching mathematics. Reston, VA: Author.

Table 1

Profile of students in final sample

	Male	Female	Total
African-American	255	257	512
White	258	262	520
Total	513	519	1032

Table 2

Recoding for student level variables

Original Variables	Original Values	Original Labels	New Value	New Label
DSEX	1	Male	0	
	2	Female	1	
DRACE	1	White	0	
	2	African-American	1	
		*All other categories were deleted		
PARED	1	Not graduated HS	0	No college
	2	Graduated HS	0	No college
	3	Some education after HS	1	Some college
	4	Graduated college	1	Some college
		*All other categories were deleted		
M810701b M810702b M810703b M810705b	1	Strongly agree	1	Positive
	2	Agree	1	Positive
	3	Undecided	0	Negative
	4	Disagree	0	Negative
	5	Strongly disagree	0	Negative
		*All other categories were deleted		
M810704b M810706b	1	Strongly agree	0	Negative
	2	Agree	0	Negative
	3	Undecided	0	Negative
	4	Disagree	1	Positive
	5	Strongly disagree	1	Positive
		*All other categories were deleted		

Table 3

Recoding for instructional practice variables

Original Variables	Original Values	Original Labels	New Value	New Label
T044502	1	Almost every day	1	Frequent
T044503 T044507	2	Once or twice a week	1	Frequent
T044510 T044512	3	Once or twice a month	0	Infrequent
T044702	4	Never or hardly ever	0	Infrequent
	8	Omitted	Deleted	
	0	Multiple response	Deleted	

Table 4

Average within-class predictors of computation and geometry achievement

WITHIN-CLASS PARAMETER	Computation	Geometry
INTERCEPT	255.06**	237.33**
RACE-ETHNICITY	-19.80**	-24.36**
SEX	-3.17	-6.32**
ATTITUDE TOWARD MATH	24.47**	24.27**
PARENT EDUCATION	7.17**	6.43**

Note:**probability ≤ .01

Table 5

Average final estimates of variance components

WITHIN-CLASS PARAMETER	Computation	Geometry
INTERCEPT	403.94**	446.24**
RACE-ETHNICITY	23.29*	37.81*
SEX	26.27	13.86
ATTITUDE TOWARD MATH	92.09	181.61
PARENT EDUCATION	14.96	25.12

Note:**probability ≤ .01; *probability ≤ .05

Table 6

Classroom characteristics predictors of average classroom achievement for computation and geometry

WITHIN-CLASS PARAMETER Between-class predictor	Computation	Geometry
INTERCEPT		
Intercept	255.52**	237.72**
Avg. attitude toward math	44.91**	49.41**
Proportion African-American	-35.17**	-49.50**
Avg. parent education	16.89**	11.08
Ability of class	3.60**	1.48
Parameter Variance	112.21**	105.32**
Proportion of Parameter Variance Explained	.72	.76

Note: **probability ≤ .01

Table 7

Classroom characteristics predictors of within-class race-ethnicity parameter for computation and geometry

WITHIN-CLASS PARAMETER Between-class predictor	Computation	Geometry
RACE-ETHNICITY		
Intercept	-21.48**	-26.10**
Avg. attitude toward math	3.62	2.65
Proportion African-American	-25.76*	-29.20*
Avg. parent education	-10.01	-21.01
Ability of class	0.46	1.58
Parameter Variance	10.11†	30.93†
Proportion of Parameter Variance Explained	.57	.18

Note: **probability ≤ .01; *probability ≤ .05; †probability ≤ .10

Table 8

Instructional practice predictors of average classroom achievement for computation and geometry

WITHIN-CLASS PARAMETER Between-class predictor	Computation	Geometry
INTERCEPT		
Intercept	249.00**	232.34**
Worksheet	-7.51†	-7.18
Small group	1.94	0.50
Manipulative	4.87	4.17
Writing	-8.40	-10.32†
Reallife problems	0.05	5.29
Assessment	13.59*	9.08
Parameter Variance	353.00**	395.17**
Proportion of Parameter Variance Explained	.13	.11

Note: **probability ≤ .01; *probability ≤ .05; †probability ≤ .10

Table 9

Instructional practice predictors of within-class race-ethnicity parameter for computation and geometry

WITHIN-CLASS PARAMETER Between-class predictor	Computation	Geometry
RACE-ETHNICITY		
Intercept	-18.39†	-22.72†
Worksheet	-4.47	-8.30
Small group	-1.94	-0.13
Manipulative	11.12	0.31
Writing	-3.14	-1.13
Reallife problems	1.86	2.13
Assessment	0.99	2.78
Parameter Variance	21.49	75.27
Proportion of Parameter Variance Explained	.08	.00

Note: †probability ≤ .10

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