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ABSTRACT

The purpose of this study was to examine the relationships between the use of technology and student computation and geometry achievement. The study also examined possible relationships between achievement differences related to demographic and background characteristics of the students and the use of technology. The sample of 956 students in eighth grade was drawn from the 1992 Trial State Mathematics Assessment for Mississippi. The technology-related variables included were the availability of computers, the type of computer use, and the frequency with which computers and calculators were used. The measures of mathematics achievement used included the plausible value estimates for the numbers and operations and geometry subscales of 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 as well as significant differences between males and females for geometry. Four classroom characteristics were associated with average computation achievement, and three were associated with average geometry achievement. Results indicate significant negative associations for the frequent use of computers and using computers for drill and practice. (Author)

The Effects of Computers and Calculators on Computation and Geometry Achievement

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Abstract

The purpose of this study was to examine the relationships between the use of technology and mathematics achievement. The sample of 143 teachers and 956 students were drawn from the 1992 Trial State Mathematics Assessment for Mississippi. The technology related variables included in this study were the availability of computers, the type of computer use, and the frequency with which computers and calculators were used. The measures of mathematics achievement used in this study included the plausible value estimates for the numbers and operations and geometry subscales of 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 as well as significant differences between males and females for geometry. The results also show that four classroom characteristics were associated with average computation achievement and three were associated with average geometry achievement. Finally, the results indicate significant negative associations for the frequent use of computers and using computers for drill and practice.

The Effects of Computers and Calculators 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 technology use 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 computers 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 technology. This study modifies the analyses conducted in the MSU project by treating classrooms as the second level of analysis, including additional variables related to technology use, 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 technology use among 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 use of technology.

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 technology used by the teachers of the assessed students. The sample used in this study consisted of 143 teachers and 956 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 four variables related to the technology use 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.

The four technology use variables were recoded according to Table 3. The final technology variables were dichotomized so that the coefficients could be interpreted as achievement differences. The final variables included the frequent or infrequent use of computers and calculators, the availability of computers, and the type of computer use.

Insert Table 3 About Here

Analysis

This study utilized a series of two level hierarchical linear models to examine possible associations between classroom characteristics, technology use, 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 eighth grade classes before any classroom characteristic or technology related variables were included. The second type of model was the conditioned model and contained the intercept as well as the classroom characteristic or technology related 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

The results of the unconditioned models for computation and geometry achievement are contained in Table 4. The average within-class achievement for computation was 254.74. The results show that African-American students scored on average 22.01 points, $t = -7.28$, $p \leq .01$, below White students. Additionally, students with at least one parent with some post-high school education averaged 7.70 points, $t = 3.27$, $p \leq .01$, higher than students whose parents did not have post-high school education. The results also show that the student's attitude toward mathematics was positively associated with computational achievement, $t = 4.99$, $p \leq .01$.

Insert Table 4 About Here

The results of the unconditioned model for geometry are similar to those for computation. The average within-class achievement in geometry was 237.15 and the race-ethnicity coefficient indicates that African-American students scored 25.86, $t = -7.81$, $p \leq .01$, points below White students. Like the parent education coefficient for computation, the difference between the geometry achievement of students with at least one parent having some post-high school education and students whose parents did not have post-high school education was 7.82, $t = 2.90$, $p \leq .01$. The coefficient for student attitude toward mathematics indicated a positive association, $t = 4.31$, $p \leq .01$. Finally, the coefficient for student sex, $t = -2.34$, $p \leq .01$, indicated that females achieved five points lower than males.

The averaged final estimates of the variance components for the unconditioned computation and geometry models are illustrated in Table 5. In the computation model, the variance component associated with the intercept or average classroom achievement was 355.86, $\chi^2(46) = 155.87$, $p \leq .01$. The results also show that the variance components for the remaining parameter estimates in the computation model were not statistically significantly different from zero.

Insert Table 5 About Here

Like the variance component associated with the intercept in the computation model, the variance component associated with the intercept in the geometry model was statistically significant, $\chi^2(46) = 134.82$, $p \leq .01$. In addition to the intercept, the variance components associated with the race-ethnicity, $\chi^2(46) = 29.75$, $p \leq .05$, and sex, $\chi^2(46) = 33.31$, $p \leq .10$, parameters were statistically significant. Based on the results of the chi-square tests for the variance components, classroom characteristic and technology use models were constructed for the intercept parameter for computation and geometry. However, classroom characteristic and technology use models were constructed for the race-ethnicity and sex parameters associated only with geometry achievement.

Classroom characteristics models

Table 6 contains the results of the classroom characteristic models for the average computation and geometry achievement. The table shows that the four classroom characteristic predictors were statistically significant. The results indicate classes with more positive attitudes toward mathematics were associated with higher average computation achievement, $t = 2.88$,

$p \leq .01$. The results further illustrate that classes with higher percentages of African-American students were associated with lower average computation achievement, $t = -8.24$, $p \leq .01$. The two remaining predictors, average parent education, $t = 2.93$, $p \leq .01$, and ability of class, $t = 2.77$, $p \leq .01$, were positively associated with average computational achievement. The results also show that the remaining parameter variance in the computation model was statistically significantly different from zero, $\chi^2(42) = 139.59$, $p \leq .01$. Additionally, the classroom characteristics model explained 70% of the parameter variance that remained after the unconditioned model.

Insert Table 6 About Here

The results in Table 6 also show that three of the four classroom predictors were statistically significantly associated with average geometry achievement. Like the computation model, the attitude of the class toward mathematics was positively associated with average geometry achievement, $t = 3.08$, $p \leq .01$. Furthermore, classes with higher proportions of African-American students were associated with lower average geometry achievement, $t = -8.48$, $p \leq .01$. Finally, classes with higher percentages of students with at least one parent receiving some post-high school education were associated with higher average geometry achievement, $t = 1.97$, $p \leq .05$. The parameter variance in the geometry model was also statistically significantly different from zero, $\chi^2(42) = 119.05$, $p \leq .01$, and the model explained 69% of the parameter variance that remained after the unconditioned model.

Table 7 contains the results of the classroom characteristics model for the race-ethnicity and sex parameters in geometry. The analyses yielded no statistically significant associations between the classroom characteristic predictors and achievement differences between African-American and White or male and female students. Furthermore, the model failed to explain any of the parameter variance associated with the race-ethnicity parameter that remained after the unconditioned model. Despite the lack of significant predictors in the sex parameter model, the classroom characteristic model was able to explain 74% of the variance that remained after the unconditioned model.

Insert Table 7 About Here

Technology use models

The results of the technology use models for the average computation and geometry achievement are presented in Table 8. The table shows that two of the four predictors were statistically significantly associated with average computation achievement. Specifically, the

frequent use of computers, $t = -2.47$, $p \le .01$, and reporting drill and practice as the primary use of computers, $t = -2.06$, $p \le .05$, were associated with lower average computation achievement. Similar results were obtained for geometry achievement. The frequent use of computers, $t = -2.16$, $p \le .05$, and reporting drill and practice as the primary use of computers, $t = -1.72$, $p \le .10$, were associated with lower average geometry achievement.

Insert Table 8 About Here

Table 8 also indicates that the parameter variance for the intercept in each equation was statistically significantly different from zero. Additionally, the technology use model explained 6% of the parameter variance that remained after the unconditioned model for computation, and despite the presence of two significant associations, the technology use model failed to explain any of the parameter variance that remained after the unconditioned model for geometry achievement.

Table 9 contains the results of the technology use models for the race-ethnicity and sex parameters for geometry achievement. The results show no statistically significant associations between the technology use predictors and the differences between African-American and White or male and female students. The table also illustrates that the remaining parameter variance was not statistically significantly different from zero. Furthermore, the technology use model failed to explain any of the parameter variance that remained from the unconditioned model for the race-ethnicity parameter and explained 17% of the parameter variance that remained for the sex parameter.

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 achievement and the use of technology. In addition, possible relationships between classroom characteristics and mathematics achievement were explored. Through the use of hierarchical linear modeling, relationships were identified for the average computation and geometry achievement. However, the models for achievement differences between African-American and White and male and female students revealed no significant relationships.

The models for average class achievement revealed significant relationships for classroom characteristic predictors as well as technology related variables. The results showed that classes who were perceived by their teachers as higher ability classes were associated with

higher average computation scores. The results also indicated that classes with more positive attitudes toward mathematics and larger proportions of students with at least one parent with some post-high school education were associated with higher computation and geometry scores. However, the results also showed that classes with higher proportions of African-American students were associated with lower computation and geometry scores. For the technology related variables, the results indicated that classes who used computers frequently or primarily used computers for drill and practice were associated with lower average 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 technology used by eighth grade teachers 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 use of technology, 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 technology use 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 technology use. 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	235	224	459
White	241	256	497
Total	476	480	956

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 technology related variables

Original Variables	Original Values	Original Labels	New Value	New Label
T044505 T044506	1	Almost every day	1	Frequent
	2	Once or twice a week	1	Frequent
	3	Once or twice a month	0	Infrequent
	4	Never or hardly ever	0	Infrequent
		*All other categories were deleted		
T045201	1	Not Available	0	Not available
	2	Difficult	1	Available
	3	Available in class	1	Available
		*All other categories were deleted		
T045102	1	Drill and practice	1	Drill and practice
	2	Learning new topics	0	Other
	3	Display, interpreting	0	Other
	4	I do not use computers	0	Other
		*All other categories were deleted		

Table 4

Average within-class predictors of computation and geometry achievement

WITHIN-CLASS PARAMETER	Computation	Geometry
INTERCEPT	254.74**	237.15**
RACE-ETHNICITY	-22.01**	-25.86**
SEX	-2.48	-5.63*
ATTITUDE TOWARD MATH	26.89**	26.46**
PARENT EDUCATION	7.70**	7.82**

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

Table 5

Average final estimations of variance components for computation and geometry achievement

WITHIN-CLASS PARAMETER	Computation	Geometry
INTERCEPT	355.86**	257.00**
RACE-ETHNICITY	42.78	15.11*
SEX	27.56	60.08†
ATTITUDE TOWARD MATH	165.37	264.06
PARENT EDUCATION	87.71	88.70

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

Table 6

Classroom characteristics predictors of average classroom achievement for computation and geometry

WITHIN-CLASS PARAMETER Between-class predictor	Computation	Geometry
INTERCEPT		
Intercept	254.92**	237.15**
Avg. attitude toward math	38.85**	39.01**
Proportion African-American	-32.65**	-45.33**
Avg. parent education	17.57**	12.42*
Ability of class	4.13**	2.20
Parameter Variance	106.06**	80.32**
Proportion of Parameter Variance Explained	0.70	0.69

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

Table 7

Classroom characteristics predictors of student-level parameters of race-ethnicity and sex for geometry achievement

	WITHIN-CLASS PARAMETER	
Between-class predictor	RACE-ETHNICITY	SEX
Intercept	-28.19**	-6.57**
Avg. attitude toward math	-14.81	19.92
Proportion African-American	-26.30	-5.93
Avg. parent education	-15.43	-13.93
Ability of class	1.68	-1.99
Parameter Variance	62.11	15.33
Proportion of Parameter Variance Explained	0.00	0.74

Note: **probability ≤ .01

Table 8

Technology predictors of average classroom achievement for computation and geometry

WITHIN-CLASS PARAMETER Between-class predictor	Computation	Geometry
INTERCEPT		
Intercept	256.99**	238.80**
Availability of computers	6.64	6.67
Frequent use of computers	-14.78*	-15.39*
Use for drill and practice	-11.56*	-10.06†
Frequent use of calculators	0.54	2.02
Parameter Variance	335.57**	315.21**
Proportion of Parameter Variance Explained	0.06	0.00

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

Table 9

Technology predictors of student-level parameters of race-ethnicity and sex for geometry achievement

	WITHIN-CLASS PARAMETER	
Between-class predictor	RACE-ETHNICITY	SEX
Intercept	-26.46**	-6.03†
Availability of computers	0.64	2.62
Frequent use of computers	-2.07	-1.58
Use for drill and practice	-0.31	1.93
Frequent use of calculators	4.54	2.62
Parameter Variance	75.86	49.32
Proportion of Parameter Variance Explained	0.00	0.17

Note: **probability ≤ .01

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