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Is Teacher Quality Related to Eighth-Grade Mathematics Achievement?

Evidence from the 2007 NAEP Data

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Abstract

This study was designed to examine the impact NCLB defined teacher-quality variables (1) major/minor in mathematics, (2) highest academic degree, (3) type of teaching certificate, (4) years taught mathematics (NCLB, 2001) on the mathematics average scale scores of eighth-grade students. The study used a secondary analysis of the 2007 National Assessment of Educational Progress (NAEP). Results were reported in terms of statistical significance (*p*. <01) and effect size (Cohen's *d*). This study found that an eighth-grade mathematics teacher is more effective with (1) either a major or minor in mathematics, (2) a Professional degree, (3) a Regular/standard teaching certificate, and (4) with 20+ years of teaching mathematics experience. The teacher quality variables had an impact on the average scale scores of students who took the 2007 NAEP eighth-grade mathematics test (national data used in the secondary analysis).

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Evidence from the 2007 NAEP Data

The No Child Left Behind (NCLB) Act (2001) included "teacher quality" as a major factor that is likely to affect student learning. Teacher quality was defined by NCLB in terms of teacher credentials. For mathematics teachers, these were: (1) major/minor in mathematics, (2) highest academic degree, (3) type of teaching certificate, (4) years taught mathematics (NCLB, 2001). This manuscript explores the impact of these defined variables on the average mathematics scale scores of eighth-grade students measured by the 2007 National Assessment of Educational Progress (NAEP). The national dataset was used for this secondary analysis.

Review of the Literature

Researchers recently reported that the quality of the teacher in the classroom was the most important predictor of student achievement (e.g., Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Hanhushek, Kain, & Rivkin, 1998).Wayne and Youngs (2003) found strong links between the NCLB-defined teacher quality variables and student achievement.

Papanastasiou (2008) examined the Trends in International Mathematics and Science Study (TIMSS) data and found that teaching was the factor that accounted for the greatest differences between more effective and less effective schools were teaching. Clotfelter, Ladd, and Vigdor (2007) performed a longitudinal analysis of a 10-year administrative dataset from North Carolina. They concluded that a teacher's (1) experience, (2) test scores and (3) regular licensure all had positive impacts on student achievement; The impact was larger on math achievement than on reading achievement. The three teacher measures combined had larger effects on mathematics achievement than either class size or the socio-economic characteristics of students.

Klecker (2007) found statistically significant (*p*. <01) differences, with moderate effect sizes, in the eighth-grade mathematics achievement by teacher-quality measures. However, a later analysis of Kentucky fourth-grade reading scores by teacher quality variables found no differences in scores by teacher quality (Klecker, 2008).

Method

Data Source

The National Assessment of Educational Progress (NAEP) has since 1969, been the only nationally representative and continuing assessment of what America's students know in various subject areas. The No Child Left Behind Act (2002) required participation of all school receiving Title I money from federal funds. This requirement has enlarged the data base. In 2005, teacher questionnaire data were added to include the NCLB-defined teacher quality variables. These teacher-quality variables were retained in the 2007 NAEP data (NCES, 2008).

Data Analysis

The researcher attended training to analyze the unique NAEP data in June 2007. During this visit, the data analyses of NAEP of 2005 data were performed. For the follow-up of the secondary analysis of the 2007 NAEP scores, the researcher used --as advised by NAEP training staff-- the NAEP Data Tool available on the NAEP website. [Note: IRB approval was obtained for this study.]

Results

Tables 1 and 2 presents the results of the analysis of average scale scores of national eighth-grade mathematics scores by the first NCLB teacher quality variable "major/minor in mathematics." Table 1 presents the descriptive statistics and Table 2 presents the results of a regression analysis.

Table 1

Average Scale Scores in Eighth-Grade Mathematics by Teacher Undergraduate Major/Minor in Mathematics

Category	Average Scale Score	SD
Major	287	35
Minor/emphasis	284	35
Neither	278	36

Table 2

Statistically Significant (p. <.01) Differences in Eighth-Grade Average Scale Scores by Undergraduate Major/Minor in Mathematics

	Major		Minor/emphasis		Neither	
Major	----		*p.* =0.000	***d*=0.09**	*p.* =0.000	***d*=0.25**
Minor/emphasis	*p.* =0.000	***d*=0.09**	---		*p.* =0.000	***d*=0.17**
Neither	*p.* =0.000	***d*=0.25**	*p.* =0.000	***d*=0.27**	----	

The analysis presented in Table 2 indicates that there is a small effect (*d*=0.09) in the test scores reflecting the difference between the students of the teacher holding a major in mathematics and the students of the teacher holding a minor in mathematics. However, the effect on student scores from a mathematics teacher holding either a major (*d*=0.25) or a minor (*d*=0.27) in mathematics is greater than having neither. Thus, a mathematics teacher is more effective with either a major or minor in mathematics.

Tables 3 and 4 below present the descriptive statistics and inferential statistics respectively for the NCLB teacher quality variable "highest academic degree."

Table 3

Average Scale Scores in Eighth-Grade Mathematics by Teacher's Highest Academic Degree

Category	Average Scale Score	SD
High School Diploma	271	28
Associate/Vocational Cert.	252	39
Bachelor's Degree	280	35
Master's Degree	285	36
Educational Specialist	280	37
Doctorate	279	39
Professional	300	41

Table 4

Statistically Significant (p. =01) Differences in Eighth-Grade Average Scale Scores by Highest Academic Degree

Professional Degree	Associate/Vocational Certification	*p*. =0.0031	Cohen's ***d* = 1.20**
Master's Degree	Bachelor's Degree	*p*. =0.0000	Cohen's ***d* = 0.14**
Master's Degree	Educational Specialist	p=0.0003	Cohen's ***d* = 0.14**

There were only three statistically significant (*p*. <01) differences between categories of this variable (Table 4). The large effect size (*d*=**1.20**) between the average scale scores of students whose teachers had an Associates degree or vocational certification and the average scale scores of students whose teachers had a Professional degree is remarkable. It is also remarkable that there were no other statistically significant differences between the other categories.

Tables 5 and 6 present the descriptive statistics and inferential statistics respectively for the NCLB teacher quality variable "type of teaching certificate" and the average scale score in eighth-grade mathematics.

Table 5

Average Scale Scores in Eighth-Grade Mathematics by Type of Teaching Certificate

Category	Average Scale Score	SD
Regular/standard	284	35
Probationary	278	35
Provisional	272	35
Temporary	266	35
Emergency	258	36
No Certificate	284	37

Table 6

Statistically Significant (p. =01) Differences in Eighth-Grade Average Scale Scores by Type of Teaching Certificate

Regular/standard	Probationary	*p*. = 0.0000	***d*=0.17**
Regular/standard	Provisional	*p*. = 0.0000	***d*=0.34**
Regular/standard	Temporary	*p*. = 0.0000	***d*=0.51**
Regular/standard	Emergency	*p*. = 0.0000	***d*=0.73**
Probationary	Provisional	*p*. = 0.0000	***d*=0.17**
Probationary	Temporary	*p*. = 0.0000	***d*=0.34**
Probationary	Emergency	*p*. = 0.0000	***d*=0.57**
Provisional	Temporary	*p*. = 0.0000	***d*=0.17**
Provisional	Emergency	*p*. = 0.0000	***d*=0.39**
Temporary	Emergency	*p*. = 0.0000	***d*=0.23**
No Certificate	Provisional	*p*. = 0.0000	***d*=0.33**
No Certificate	Temporary	*p*. = 0.0000	***d*=0.50**
No Certificate	Emergency	*p*. = 0.0000	***d*=0.71**

The effect sizes for the differences between the average scale scores across categories range from small (0.17 - 0.23) to medium (0.34 - 0.51) to large (0.73) (Cohen, 2001). It is a surprising finding that the eighth-grade mathematics students of teachers with no teaching certification have statistically significantly higher average mean scores with moderate to high

effect sizes when compared with the students of teachers with Provisional, Temporary, and Emergency Teaching Certificates.

Table 7 and 8 below present descriptive and inferential statistics for differences in average scale scores in eighth-grade mathematics and the NCLB teacher quality variable "years taught math."

Table 7.

Average Scale Scores in Eighth-Grade Mathematics by Years Taught Mathematics

Category	Average Scale Score	SD
0-4 Years	276	35
5-9 Years	282	35
10-19 Years	285	35
20+ Years	289	35

Table 8.

Statistically Significant (p. =01) Differences in Eighth-Grade Average Scale Scores by Type of Teaching Certificate

20+ Years	10-19 Years	*p.* =0.000	***d*=0.11**
20+ Years	5-9 Years	*p.* =0.000	***d*=0.20**
20+ Years	0-4 Years	*p.* =0.000	***d*=0.37**
10-19 Years	5-9 Years	*p.* =0.000	***d*=0.09**
10-19 Years	0-4 Years	*p.* =0.000	***d*=0.26**
5-9 Years	0-4 Years	*p.* =0.000	***d*=0.17**

The effect sizes range from small (0.11-0.26) to moderate (0.37) (Table 8). The effect sizes increase as the years of teaching experience increase. In the NAEP database, years-of-teaching-experience is available as a continuous variable. The categories presented are the categories available through the NAEP Data Tool.

Conclusions

This secondary analysis of the NAEP 2007 eighth-grade mathematics national dataset average scale scores found statistically significant ($p.<01$) differences by NCLB-defined teacher-quality variables. Because of the large N in the dataset, the best measure of real differences is Cohen's *d*. Even small effect sizes indicate areas for future research (Cohen, 2001).

Undergraduate Major or Minor in Mathematics

The analysis found a small effect for the NCLB variable "major or minor in mathematics." The effect on student scores of a mathematics teacher holding either a major (d=0.25) or a minor (d=0.27) in mathematics is greater than having neither. However, the effect size between having a major and having a minor is very small (d=.09). Thus, an eighth-grade mathematics teacher is more effective with either a major or minor in mathematics.

Teacher's Highest Academic Degree

This analysis yielded rather puzzling results (Table 4). The only statistically significant ($p.$ <01) differences were between Professional Degree and Associate Degree/Vocational Certification, with a large effect size (d=1.20). The difference between the scores of the students being taught by a teacher with a Master's or a Bachelor's Degree was statistically significant, yet with a small effect size (d=0.14). The same statistical significance and effect size was found for the comparison of student scores of a teacher holding a Master's Degree and a teacher holding an Educational Specialist Degree.

Type of Teaching Certificate

There were many statistically significant differences between the six categories in this variable. The average scale score was highest for the students of teachers holding either the Regular/Standard Certificate (M=284, SD=35) or No Certificate (M=284, SD=35). The lowest average scale score (M=266; SD=35) was for the students of mathematics teachers holding a Temporary certificate. The largest effect size (d=0.73) was the effect of the teacher holding Regular/Standard certification rather than Emergency Certification. The puzzle of the high average scale score for students of teachers holding No Certification calls for further exploration of the data and the variable definitions.

Years Taught Mathematics

The eighth-grade students who were taught by teachers with the most (20+) years-of-teaching experience has the highest average scale score. The largest effect size (d=0.37) was between the average scale score of students of teachers with 20+ years-of-teaching-experience (289) and the average scale score of students of teachers with 0-4 years-of-teaching-experience (276). The analysis of these data found that the students' scores increased with their teachers' years-of-teaching experience.

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