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Educational Equity and Adequacy for Disadvantaged Minority Students: School and Teacher Resource Gaps Toward National Mathematics Proficiency Standard

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ABSTRACT. This study addresses the issue of educational inadequacy and inequity for disadvantaged minority students. It estimates desired national standards and examines interrelated gaps in key school–teacher resources and mathematics achievement by linking national education data sets (National Assessment of Educational Progress [NAEP], Common Core of Data, and Schools and Staffing Survey). Although poor minority students’ chances to meet the national mathematics proficiency standard are undermined by the lack of their access to qualified teachers and adequate school funding, it turns out that the adequacy-based (absolute) gaps are much larger than the equity-based (relative) gaps. Meeting the NAEP Grade 8 mathematics proficiency standard requires substantial increases in per-pupil education spending (from $6,493 to $7,197 in year 2000 dollars) and in-field mathematics teaching rate (from 49% to 91%) across the nation. Research and policy implications are discussed.

Keywords: adequacy, achievement gap, equity, poverty, race

Achievement gaps constitute important barometers in educational and social progress. The No Child Left Behind Act of 2001 (NCLB) provides new opportunities and challenges to advance the goal of closing the achievement gap. It holds schools accountable for making adequate yearly progress (AYP) toward the goal of 100% proficiency. NCLB also requires that all teachers in core academic subjects be highly qualified. Despite these policy imperatives and fiscal investments from the federal government, many states and districts face challenges in addressing the inadequacies and disparities of school resources in order to accomplish the goals of NCLB (Education Week, 2005; National Conference of State Legislatures, 2003; National School Boards Association, 2006). Particularly, impoverished and racially segregated schools have greater difficulties meeting the standards with fewer instructional resources and less qualified teachers (Kim & Sunderman, 2004; Lee, 2007). As expectations for schools rise and money remains tight across states, one of the key policy questions is the following: What kinds and how much of extra resources are needed to meet common rigorous national standard of proficiency?

Although previous studies using various methods with data from different states suggested different cost estimates, they all revealed a need for large new investments in education spending (Mathis, 2003; Rebell, 2006). In principle, high-stakes educational accountability policies should maintain a proper balance between pressure and support so that schools cannot be held accountable for results without adequate resources. However, the past policy approaches to educational accountability tended to diverge, favoring either a primary emphasis on input guarantees as a mechanism for achieving equal access to learning opportunities, or a primary emphasis on performance guarantees for ensuring achievement outcomes (Elmore & Fuhrman, 1995; Lee & Wong, 2004; O’Day & Smith, 1993). The advocates of opportunity-to-learn (OTL) standards have argued that every student must have equal access to high-quality learning by specifying key inputs (e.g., per-pupil spending, textbooks, teacher training) in the form of binding standards (Porter, 1995). In contrast, the critics of OTL standards contended that holding schools and students accountable for performance creates incentives for schools to discover which practices work most effectively (Hanushek, 1997). Despite these controversies, some studies suggested that the two approaches are not mutually exclusive, and combining them can be a more successful path for closing the achievement gap (Bartman, 2002; Lee, 2006).
National progress toward closing the achievement gap can be monitored through the National Assessment of Educational Progress (NAEP), the nation's report card of student achievement in key subject areas. It provides information on the achievement gap among racial and socioeconomic groups of students based on nationally representative samples. For example, the 2000 NAEP report not only shows that the percentage of Black students performing at or above Proficient level in mathematics was lower than that of their White peers (34% for Whites vs. 5% for Blacks at Grade 4, 35% for Whites vs. 6% for Blacks at Grade 8, 20% for Whites vs. 3% for Blacks at Grade 12), but also shows that the majority of Black students failed to meet the proficiency standard (National Center for Education Statistics [NCES], 2001). It draws attention to equity and adequacy, that is, not only reducing the racial gap in test scores but also reducing each minority student groups’ chance of failing to meet desired performance standards.

At the same time, other national education databases from the NCES, such as the Common Core of Data (CCD) F-33 and the Schools and Staffing Survey (SASS), can provide contextual information on key schooling conditions and resources that would enable students to meet national performance standards. CCD F-33 data provides school district demographics and funding information. Prior research using the CCD F-33 data has shown that school districts with predominantly poor students and Black or Hispanic students generally tend to spend less on education than their predominantly advantaged and White counterparts (Carey, 2004; Lee & Wong, 2004). On the other hand, SASS provides information on teacher qualification, including the rate of in-field teaching—the percentage of teachers with an undergraduate or graduate major and subject matter certification in the subject they teach (NCES, 2002). Teachers in schools with a relatively larger percentage of students who were eligible for free or reduced-price lunch tended to be less qualified for teaching the subjects of main assignment (Jerald, 2004). The opportunity of being taught by qualified teachers is also lower for predominantly minority schools (Lee & Wong, 2004).

Triangulation of these multiple sources of data has potential for enriching interpretations of achievement gaps in the nation's report card and drawing increasingly valid inferences about the level of resources needed to close the achievement gaps. Nevertheless, the discrete and disjointed nature of information from these different national data sources has prevented researchers from combining them for an integrated analysis of relationships among resources and achievement gaps. In light of these concerns, we conducted a synthetic analysis of the distributions of school/teacher resources and student achievement by linking NAEP to the CCD and SASS, which contain information on school and teacher resources. Particular attention was paid to school funding and in-field teaching. These are policy-manipulable factors that are deemed crucial for closing the achievement gaps (see Ferguson, 1991; Goldhaber & Brewer, 1997; Hedges, Laine, & Greenwald, 1994; Lee & Wong, 2004). The research considers racial and socioeconomic gaps from adequacy and equity perspectives for improving the distributions of school resources and student achievement outcomes. Simply reducing disparities between groups in their test scores and learning opportunities is not a success; there must be improvement in the adequacy of resources for low-achieving, disadvantaged minority groups to meet desired performance standards. Researchers need to understand whether the distributions of school/teacher resources and student achievement are equitable and adequate as well as how well the nation accomplishes these two goals simultaneously.

The present study proposes that the achievement gap be assessed from adequacy and equity perspectives. Equity focuses on relative achievement of different groups of students. Despite the narrowing of the relative gap among different racial and socioeconomic groups, some minority students do not perform at an acceptable level of achievement. Thus, I also examine achievement gap from an adequacy perspective as well that mainly investigate how well students perform in absolute terms against desired achievement level. This adds a new dimension of gap relative to adequate performance, eliminating the possibility of lowering the achievement of the higher performing group to close the relative gap. As with student achievement gaps, it is necessary to ask the same kind of question about educational opportunity gaps: How equitable and adequate are the distributions of key school and teacher resources for disadvantaged minority students? The present study asks that policymakers address the double jeopardy of educational inequalities and inadequacies for disadvantaged minority students under the new school accountability system with increasingly higher standards and tighter resources.

Since the Coleman Report in the 1960s brought attention to racial and socioeconomic inequity in student outcomes, the achievement gap issue has raised a multitude of concerns and resulted in a significant body of empirical research (see Coleman et al., 1966; Jencks & Phillips, 1998). Although the conventional research on racial achievement gaps focuses on the issue of equity, this approach alone has limitations. Although there has been significant national progress over the past three decades in narrowing Black–White and Hispanic–White achievement gaps, the progress occurred when White students did not make progress as well. Furthermore, the academic progress of Black and Hispanic students occurred mostly below the minimum competency level of achievement (Lee, 2002).

Over the past two decades of standards-based educational reform, many states attempted to raise the standards of student learning from minimum competency with an emphasis on basic skills to proficiency with an emphasis on disciplined knowledge and higher order thinking skills (Fuhrman, 1999; Ravitch, 1995). Despite the policy rhetoric and bandwagon, prior research showed significant discrepancies between NAEP and state assessment results, suggesting that...
for many states, NAEP proficiency levels are more challenging than the states’ own (Fuller, Gesicki, Kang, & Wright, 2006; Klein, Hamilton, McCaffrey, & Stecher, 2000; Linn, Baker, & Betebenner, 2002; NCES, 2007). Because state standards vary widely in terms of the meaning and level of proficiency, generalizable inferences cannot be made about student achievement based on state assessment results only (Linn, 2000). Moreover, the rigor of the present state standards and assessment has been questioned in terms of preparing students for postsecondary education (ACT, 2005).

There have been attempts to estimate the costs of raising all children’s test scores to a particular state’s standard (see Duncombe, Ruggiero, & Yinger, 1996; Guthrie & Rothstein, 1999; Reschovsky & Imazeki, 1998, 2004). Although previous studies of adequacy relied on states’ own student assessment and school funding data to derive an adequacy-based funding formula, large discrepancies between NAEP and state assessment results on achievement level pose a threat to the validity of adequacy estimations based solely on states’ own standards and assessment results (Lee, 2010). Given the present policy movement toward adopting common rigorous national standards across all states (i.e., the Race to the Top program), it would be timely and meaningful to assess the adequacy of school and teacher resources based on the NAEP proficiency standard, which serves as the only independent national barometer of student achievement in core subjects.

Although researchers disagree on the best measure of school/teacher quality and the significance of school/teacher effects, a great deal of evidence suggests systematically positive effects of instructional resources and teacher quality on academic achievement (Ferguson, 1991; Hedges et al., 1996). In-field teaching turned out to be a strong predictor of student achievement (Darling-Hammond & Post, 2000; Goldhaber & Brewer, 1997). Previous studies also demonstrated disparities and inadequacies in terms of school funding or teacher quality for disadvantaged minority groups (Berne, 1994; Brennan, 2002; Darling-Hammond & Post, 2000; Education Trust, 2003; Hanushek, Kain, & Rivkin, 2001; Haycock, Gerald, & Huang, 2001; Ingersoll, 1996; Lankford, Loeb, & Wyckoff, 2002; Lee & Wong, 2004). Poor minority students are often double-bound by problems with less adequate instructional resources and less qualified teachers in their schools along with challenges posed by their relatively disadvantaged home learning environment. However, the challenge is to identify unique educational needs for different racial and socioeconomic groups of students and to fill the gaps based on a commonly linked national standard of achievement and resources.

Method

Samples and Variables

The primary data sources includes the 2000 NAEP state Grade 8 mathematics assessment with representative samples of students and schools in 39 states; among those other 11 states, 10 did not participate in that assessment (Alaska, Colorado, Delaware, Florida, Iowa, New Hampshire, New Jersey, Pennsylvania, South Dakota, Washington), whereas one state (Wisconsin) failed to meet the initial school participation rate of 70% and thus results were not reported (NCES, 2001).

The student composite score on the total mathematics assessment is used as a measure of student achievement in mathematics. NAEP used item response theory (IRT) to estimate proficiency scores in mathematics for each individual student; there are five plausible values for each sampled student resulting from five random draws from the conditional distribution of proficiency scores for each student. Prior research has shown that NAEP has high reliability (internal consistency reliability coefficient = .91; inter-rater agreement rate for constructed response questions = 97% at Grade 8) and concurrent validity (high correlations with state assessment scores; Lee, 2007). These mathematics achievement scores are broken down by race and ethnicity and poverty variables from NAEP; the eligibility for free or reduced-price lunch variable is used as a proxy for poverty.

Policy definition of performance standard for the NAEP’s Proficient achievement level says that students demonstrate competency over challenging subject matter, including subject-matter knowledge, application of such knowledge to real-world situations, and analytical skills appropriate to the subject matter. The NAEP achievement levels including Proficient are authorized by the NAEP legislation and adopted by the National Assessment Governing Board (NAGB); they are collective judgments, gathered from a broadly representative panel of teachers, education specialists, and members of the general public, about what students should know and be able to do relative to a body of content reflected in the NAEP assessment frameworks (Reese, Miller, Mazzeo, & Dossey, 1997). The NAEP mathematics assessment framework is based on the National Council of Teachers of Mathematics (NCTM; 1989) standards.

In addition, I drew on data from the 2000 School District Finance Survey (F-33) and the SASS. The addition of SASS and F-33 data to NAEP provides information on key school resource variables at school and district levels that are not presently available from NAEP (see http://nces.ed.gov/ccd/f33agency.asp for detailed information on F-33 and http://nces.ed.gov/surveys/sass for detailed information on SASS).

To examine the relationship between student mathematics achievement variables from NAEP and school funding variables from F-33 data, I selected an analytic subsample of schools that were common to both data sets; schools were matched with common school district identification codes. This analysis used a linking file that Westat (Rockville, MD) produced to link various years of NAEP data to CCD school district data. The purpose of the file was to provide a link
The racial and socioeconomic composition of the analytic samples used for this study represents racial and socioeconomic diversity in the full national sample (69% White, 14% Black, 10% Hispanic, 5% Asian American/Pacific Islander, 2% American Indian; 32% eligible for school lunch program, 68% ineligible). In the NAEP-CCD linked sample, the composition was 69% White, 14% Black, 10% Hispanic, 5% Asian American/Pacific Islander, and 2% American Indian for the race/ethnicity breakdown, and 33% who were eligible and 67% who were ineligible for the school lunch program in the poverty breakdown. Asian American/Pacific Islanders and American Indians were not included and reported in this study due to the lack of sufficient sample sizes for reliable analysis.

To check potential bias in this merged data due to truncation, I checked the comparability of descriptive statistics between matched and nonmatched student groups. In the NAEP-CCD linked data, there was no significant difference in mathematics achievement between the two groups; the average NAEP Grade 8 mathematics plausible value was 274 for the matched student sample (n = 80,600) and 277 for the nonmatched student sample (n = 203). In the NAEP-SASS linked data, there was also no significant difference in mathematics achievement between the two groups; the average NAEP Grade 8 mathematics plausible value was 277 for the matched student sample (n = 5,151) and 275 for the nonmatched student sample (n = 78,652). Likewise, there were no significant differences in the average per-pupil expenditures between matched and nonmatched CCD school districts and in the average in-field teaching rates between matched and nonmatched SASS schools. The results suggest that patterns of the missing data due to nonmatching were likely to be random with regard to the distributions of all three research variables, including the NAEP mathematics achievement, the CCD per-pupil expenditures, and the SASS in-field teaching.

Table 1 provides summary statistics of all the variables by racial and socioeconomic subgroups in the final analytical sample as merged from those three separate data sources. The estimate of national average NAEP Grade 8 mathematics achievement was 275. The estimate of national average current educational expenditures per pupil in 2000 dollars was $6,493. According to the Digest of Education 1999–2000 school report (NCES, 2000), PPE in public elementary and secondary schools was $7,392 based on average daily attendance and $6,911 based on full enrollment (in year 2000 dollars). This reported national average PPE based on full enrollment was somewhat higher than the CCD sample average PPE of $6,493. The discrepancy may be attributable to the sample difference; the government report included all districts, whereas the analytical sample included only districts that include schools that participated in the 2000 Grade 8 NAEP. At the same time, the estimate of national average school in-field mathematics teaching rate was 48.1%. According to the NCES report based on 2000 SASS data (NCES, 2000), the rate of in-field teaching in middle-level mathematics was 33.2. This teacher-level average rate from the entire SASS sample was lower than the school-level average rate as estimated from the analytic sample. Other variables provide background information on demographic, family and school characteristics of the analytical sample.
### TABLE 1. Descriptive Statistics of All Variables by Racial and Socioeconomic Subgroups

<table>
<thead>
<tr>
<th>Variable</th>
<th>White</th>
<th>Black</th>
<th>Hispanic</th>
<th>Nonpoor</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics achievement</td>
<td>284.05</td>
<td>248.47</td>
<td>254.77</td>
<td>282.82</td>
<td>254.35</td>
</tr>
<tr>
<td>Per-pupil expenditures</td>
<td>6,519.02</td>
<td>6,926.33</td>
<td>6,566.70</td>
<td>6,481.96</td>
<td>6,618.04</td>
</tr>
<tr>
<td>In-field mathematics teaching</td>
<td>52.25</td>
<td>36.94</td>
<td>30.03</td>
<td>48.67</td>
<td>41.84</td>
</tr>
<tr>
<td>Median household income</td>
<td>32,953.35</td>
<td>28,738.97</td>
<td>30,851.60</td>
<td>33,739.15</td>
<td>27,949.94</td>
</tr>
<tr>
<td>Percentage of bachelor's degree or higher</td>
<td>20.76</td>
<td>21.60</td>
<td>20.60</td>
<td>21.88</td>
<td>18.82</td>
</tr>
<tr>
<td>Percentage of minority children</td>
<td>13.27</td>
<td>44.92</td>
<td>35.48</td>
<td>17.71</td>
<td>33.97</td>
</tr>
<tr>
<td>Percentage of at-risk children</td>
<td>2.44</td>
<td>6.50</td>
<td>5.19</td>
<td>2.65</td>
<td>5.44</td>
</tr>
<tr>
<td>Percentage of children below poverty</td>
<td>13.54</td>
<td>23.42</td>
<td>22.44</td>
<td>13.39</td>
<td>23.16</td>
</tr>
<tr>
<td>Percentage of children with disabilities (IEP)</td>
<td>12.79</td>
<td>7.79</td>
<td>9.64</td>
<td>11.67</td>
<td>10.57</td>
</tr>
<tr>
<td>Percentage of children with limited English proficiency</td>
<td>1.21</td>
<td>2.12</td>
<td>5.62</td>
<td>1.68</td>
<td>3.48</td>
</tr>
<tr>
<td>Total number of schools</td>
<td>32,65</td>
<td>162.23</td>
<td>174.15</td>
<td>46.68</td>
<td>139.20</td>
</tr>
<tr>
<td>Total number of students</td>
<td>24,046.04</td>
<td>126,645.80</td>
<td>159,615.40</td>
<td>37,233.77</td>
<td>117,050.40</td>
</tr>
<tr>
<td>Student–Teacher ratio</td>
<td>16.31</td>
<td>16.29</td>
<td>18.01</td>
<td>16.64</td>
<td>16.76</td>
</tr>
<tr>
<td>Cost of education index</td>
<td>0.97</td>
<td>1.01</td>
<td>1.06</td>
<td>0.99</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Analytical Models and Statistical Methods**

Figure 1 shows an analytical framework of the study. This study undertook two successive tasks. Task 1 focused on defining and measuring racial and socioeconomic gaps from an equity perspective. This task involved using the racial and socioeconomic characteristics of students to examine the distributions of school resources and mathematics achievement. Task 2 focused on defining and measuring the gaps from an adequacy perspective. In this task 1 investigated the racial and socioeconomic distributions of mathematics achievement relative to proficiency standards and the distributions of resources relative to adequacy benchmarks that correspond to proficiency standards. I used cost function analysis to predict hypothetical levels of educational spending and qualified teachers for the nation and states to achieve the Proficient level on NAEP as a common national performance standard.

Using the cost function analysis method, I conducted an empirical search for adequate levels of school funding and teacher qualification that correspond to the target proficiency level in Grade 8 mathematics. Estimation of the cost function must take into account the fact that the educational output (academic achievement) and per-pupil expenditures are determined simultaneously (see Reschovsky & Imazeki, 1998, 2004). Given the reciprocal causation problem, two-stage least squares (2SLS) regression with instrumental variables was used; the Hausman test of endogeneity was conducted to determine that estimates based on the 2SLS model are different from estimates based on the ordinal least squares (OLS) model (see Berndt, 1991; Wooldridge, 2002).
The cost function analysis method takes into account the contributions of various characteristics of school districts to the costs of education. 2SLS regression treats student mathematics proficiency variable as endogenous and turns that variable into exogenous by regressing it on instrumental variables that are assumed to be highly correlated with student mathematics proficiency but uncorrelated with theoretical errors of educational cost as the dependent variable. Although selection of the best instruments for school performance is difficult, previous educational cost function studies drew on a set of variables that were related to demand for public education (Duncombe et al., 1996; Lee, 2010; Reschovsky & Imazeki, 2004). According to the median voter model, demand for public education is seen as a function of median household income and educational preferences. As proxies for educational preferences, school districts’ social and racial composition variables were included: percentage non-White children and percentage of households with bachelor’s degree or higher. The underlying assumption is that these variables are related to voters’ willingness to pay for education and only indirectly affect the cost of education through their effects on schools’ academic performance.

Building on prior research, the amount of current educational expenditures per pupil was specified as a function of predicted mathematics proficiency and other factors that directly influence the cost of education. Those cost-related factors available from CCD data included district size (number of schools), school size (number of students), class size (student–teacher ratio), percentage of children in households below poverty, percentage of at-risk children, and percentage of children with limited English proficiency. The cost of raising the achievement of socioeconomically disadvantaged students, who are at greater risk of academic failure, is higher. The number of children and schools in the district also represent the variation in cost. Larger enrollment leads to lower costs if there are economies of scale. Controlling for enrollment, more schools may lead to higher costs because of the fixed costs of running each school (Ferguson & Ladd, 1996). Data on school district size and student demographic composition variables were drawn from the 2000 CCD. Geographic cost-of-education index was also included to adjust for regional cost differences.

Although the previous cost function-based estimation of national adequacy benchmarks for school funding or in-field teaching was based on the assumption that they are appropriate for all students, it is necessary to take into account varied educational needs among different racial and socioeconomic groups of students. To make fair comparisons, I estimated minimal educational costs separately for each racial and socioeconomic subgroup of students to reach the same mathematics proficiency standard. The results may vary by subgroup differences in educational cost and needs based on the percentage of students at risk (i.e., poverty, disabilities, or limited English proficiency). Group average values of the variables in Table 1 were used to estimate the adequacy level of school funding and in-field teaching for each group.

Because the study sample had a nested data structure (students nested within schools and school districts), it might have violated the assumption of independence of observations for regression analysis. To obtain unbiased estimators, estimation routines must take the feature of the sample design into account when computing sample statistics. I used the AM regression procedure (with NAEP ORIGWT variable for weight, NAEP REGRP1 variable for strata, and NAEP SCRPSU variable for cluster) that uses a robust variance estimator known as a weighted first-order Taylor-series linearization method (Binder, 1983) that corrects for heteroscedasticity as a result of stratified cluster sampling (see American Institutes for Research, 2010). Further, I also corrected the standard errors of coefficients from the second-stage regression of the 2SLS procedure by using a correction factor, that is, the ratio of standard errors of the estimate from regressions with actual versus predicted values of mathematics achievement (see Gujarati, 1988).

Results

Benchmarks of School Funding and In-Field Teaching for Mathematics Proficiency

The 2SLS regression analyses showed significant relationships between mathematics achievement and in-field mathematics teaching and also between mathematics achievement and per-pupil expenditures. Table 2 summarizes the results of the second-stage regression to estimate adequate levels of school funding and teacher qualification that correspond to the NAEP Proficient achievement level. In Table 2, the relationship between predicted Grade 8 mathematics proficiency from NAEP and PPE from CCD was significantly positive ($b = 21.73$, $p < .01$); a one-point increase in mathematics proficiency was associated with a $21.73$ increase in educational spending. Given this relationship, the estimate of minimally adequate school funding level to achieve the Proficient achievement level on NAEP Grade 8 mathematics (cut score of 299) was $7,197 in year 2000 dollars. This means that a district with the national average costs (all cost factors set to the national mean) must spend at least $7,197 per pupil for its students to reach the NAEP Grade 8 mathematics proficiency standard.

Table 2 also shows significantly positive relationships between predicted Grade 8 mathematics proficiency from NAEP and school in-field mathematics teaching rates from SASS ($b = 1.97$, $p < .01$); a one-point increase in mathematics proficiency was associated with a 1.97 percentage point increase in in-field teaching. The estimate of minimally adequate in-field mathematics teaching rate to achieve a Proficient mathematics achievement level on NAEP (cut score of 299) was 91%. This means that a school with the national average costs (all cost factors set to the national mean) must have at least 91% of Grades 5–8 mathematics teachers teaching in-field for its average
students to reach the NAEP Grade 8 mathematics proficiency standard.

As far as per-pupil expenditures as an outcome variable are concerned, the signs of the second-stage regression coefficients are largely consistent with hypotheses about educational cost determinants. The higher student–teacher ratio (as a proxy for class size) was associated with lower costs due to economies of scale \( (b = -51.67, \ p < .01) \). The higher percentage of students below the poverty line and students with learning disabilities indicated a greater need for spending \( (b = 32.08, \ p < .001) \). Contrary to the expectation, however, the higher percentage of students with limited English proficiency was associated with lower costs \( (b = -51.67, \ p < .01) \). The cost of education index was strongly positively associated with per-pupil expenditures \( (b = 9061.75, \ p < .001) \). The model explained 46% of the total variance in per-pupil expenditures.

In contrast, the estimated cost function for in-field teaching showed a somewhat different pattern of relationships except for the aforementioned positive effect of mathematics proficiency. Larger enrollment was associated with lower in-field teaching rates \( (b = -0.001, \ p < .001) \). Controlling for enrollment, more schools were associated with higher in-field teaching \( (b = 0.96, \ p < .05) \). The higher percentage of students at risk indicated a greater need for qualified teachers \( (b = 6.23, \ p < .05) \). The cost of education was not associated with in-field teaching rate; it was contrary to the expectation that more qualified teachers would cost more to hire. Results suggest that in-field teaching as an indicator of teacher qualification does not have the same determinants as school spending. Although there can be many different reasons for out-of-field teaching (e.g., misassignment due to teacher shortage vs. organizational structure of schools; Ingersoll, 1999), it appears that the cost factor does not influence in-field teaching in the same way that it influences overall educational spending. The model explains 12% of the total variance in in-field mathematics teaching.

The results of this second-stage regression provide educational cost (monetary and human resources) functions that can be used to estimate adequate school funding and in-field mathematics teaching levels for meeting the NAEP mathematics proficiency standard. National average values of each predictor and the value of the NAEP proficiency standard (cut score of 299) were entered into the regression equation (as shown in Table 2) for estimation.

The NAEP proficiency cut score of 299 is 24 points higher than the present national average score of 275, and the difference amounts to 73% of a standard deviation. In the present sample, approximately 24% of students met this standard. The results of estimating corresponding benchmarks for school/teacher resources revealed that achieving the NAEP proficiency goal requires significant increases in school funding and teacher qualification. If comparing the estimate of minimally adequate school funding level ($7,197) with the present national average of per-pupil expenditures ($6,493) in Table 1, the difference is $704 more than the present funding level. In the present sample, approximately 25% of students were in school districts that met this school funding standard. Likewise, if comparing the estimate of minimally adequate schoolwide in-field mathematics teaching rate (91%) with the present national average (49%) in Table 1, the difference is 42 percentage points greater than
the present qualification level. In the present sample, approximately 41% of students attended schools that met this teacher qualification standard.

**Equity- and Adequacy-Based Gaps in School Resources and Mathematics Achievement**

For reaching the common goal of the national proficiency standard, a minimally adequate level of per-pupil educational expenditures for an average student varied by race: $6,956 for Whites, $7,662 for Blacks, and $7,483 for Hispanics. The estimates of required school funding also varied by poverty status: $7,394 for poor students and $7,040 for nonpoor students. Minimally adequate level of in-field mathematics teaching rates also varied by race and poverty status: 85% for Whites, 100% for Blacks, and 85% for Hispanics; 100% for poor students and 85% for nonpoor students. Table 3 summarizes the percentage of eighth-grade students by race and poverty categories who met the NAEP proficiency standard and corresponding adequacy benchmarks for in-field teaching and per-pupil expenditures.

These group-specific estimates of adequate school funding and in-field teaching were significantly higher than actual values of the same variables shown in Table 1. The national average school funding gaps are larger for disadvantaged minority students: the gaps in percentage of qualified mathematics teachers available that were less than desired for each group to meet the NAEP mathematics proficiency standard were 33 for Whites, 63 for Blacks, and 55 for Hispanics, and 58 for poor and 36 for nonpoor students. These racial and socioeconomic gaps can be translated into the percentages of students who met the in-field teaching adequacy target: 47% for Whites, 32% for Blacks, and 24% for Hispanics, and 44% for nonpoor and 36% for poor students (see Table 3).

Racial and socioeconomic group profiles are shown across all three measures in Figures 2 and 3. The distances between different group lines represent equity-based gaps for minority students and poor students relative to their White and nonpoor counterparts, whereas distances between each group line and the ceiling (100%) represent adequacy-based gaps against the mathematics proficiency standard and corresponding school/teacher resources benchmarks. When comparing the equity-based gaps with the adequacy-based gaps for disadvantaged minority students, the disparities are much larger in relation to adequacy benchmark than to reference groups. Regarding mathematics achievement, the adequacy-based gaps for poor minority students, as measured by the gaps between the NAEP proficiency level and their present achievement level, were about 4 times greater than the equity-based gaps, as measured by the gaps relative to White and nonpoor students. A total of 70%–90% of poor minority students did not reach benchmarks for in-field mathematics teaching or school funding.

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**TABLE 3. Equity- (Relative) and Adequacy-Based (Absolute) Gaps in the Percentage of Grade 8 Minority and Poor Students Meeting the Standard in Mathematics Achievement, In-Field Mathematics Teaching, and School Funding**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Mathematics achievement</th>
<th>In-field mathematics teaching</th>
<th>School funding (PPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% meeting the standard, by race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White (W)</td>
<td>32%</td>
<td>47%</td>
<td>27%</td>
</tr>
<tr>
<td>Black (B)</td>
<td>5%</td>
<td>32%</td>
<td>25%</td>
</tr>
<tr>
<td>Hispanic (H)</td>
<td>10%</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>Relative gap for Black (W − B)</td>
<td>27%</td>
<td>15%</td>
<td>2%</td>
</tr>
<tr>
<td>Relative gap for Hispanic (W − H)</td>
<td>22%</td>
<td>23%</td>
<td>10%</td>
</tr>
<tr>
<td>Absolute gap for Black (100 − B)</td>
<td>95%</td>
<td>68%</td>
<td>75%</td>
</tr>
<tr>
<td>Absolute gap for Hispanic (100 − H)</td>
<td>90%</td>
<td>76%</td>
<td>83%</td>
</tr>
<tr>
<td>% meeting the standard, by poverty level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonpoor (N)</td>
<td>31%</td>
<td>44%</td>
<td>25%</td>
</tr>
<tr>
<td>Poor (P)</td>
<td>8%</td>
<td>36%</td>
<td>20%</td>
</tr>
<tr>
<td>Relative gap for poor (N − P)</td>
<td>27%</td>
<td>23%</td>
<td>8%</td>
</tr>
<tr>
<td>Absolute gap for poor (100 − P)</td>
<td>95%</td>
<td>92%</td>
<td>64%</td>
</tr>
</tbody>
</table>

Note. PPE = current per-pupil expenditures.
FIGURE 2. Percentages of White, Black, and Hispanic eighth-grade public school students who met the NAEP mathematics proficiency standard and corresponding in-field mathematics teaching and school funding benchmarks (adequacy gap = minority group gap against 100%; equity gap = minority group gap relative to white). PPE = current per-pupil expenditures (color figure available online).

FIGURE 3. Percentages of nonpoor and poor eighth-grade public school students who met the NAEP mathematics proficiency standard and corresponding in-field mathematics teaching and school funding benchmarks (adequacy gap = poor group gap against 100%; equity gap = poor group gap relative to nonpoor). PPE = current per-pupil expenditures (color figure available online).

Limitations

This study had several limitations. First of all, the cross-sectional nature of NAEP data requires cautious interpretations. Adding information on school resources to present NAEP national and state report cards does not warrant drawing causal inferences about the relationship between school resources and student achievement. Clearly there are potential self-selection biases. If school systems allow experienced teachers to choose the school where they will teach and those teachers prefer to teach in schools and classes with high-performing students, then a positive relationship between teacher qualifications and student achievement may not imply teacher effectiveness. Likewise, this also can happen to more qualified, well-trained new teachers who have a better chance of selecting a higher performing school. At the same time, if higher performing students (who are more likely to come from higher SES families and live in more affluent school districts) tend to go to a school with better resources and learning environments, then the relationship between school resources and achievement may reflect more of selection effects than of resource effects.

Unfortunately there was no variable from cross-sectional NAEP data that directly measured students’ prior achievement. The study’s approach to coping with the problem was to use instrumental variables to remove influences of unmeasured extraneous variables that can bring about such possible selection biases. However, the downside of using this econometric method is its technical complexity and difficulty in explaining results to policymakers.

This study also had several other data-specific limitations, which need to be considered in interpreting its results. First, I used only part of the NAEP data for estimation of school performance proficiency; this provided information on mathematics achievement outcome for one particular grade. Second, there were also limitations in combining F-33 data with NAEP. F-33 data were only available at the district level and within-district variation in school funding might have been ignored. Although few school systems collect budget information at the school level, there is a growing need for school-level spending data (see NCES, 1996). Third, although schools that participate in NAEP are randomly selected and represent the school population in each state, using this limited sample of students can cause potential bias in estimating the relationship between student achievement and school resources.

Discussion

Building on the common NAEP mathematics proficiency standard, I attempted to establish benchmarks for adequate levels of school funding and teacher qualification across the nation. At the same time, I examined disparities among different racial and socioeconomic groups based on those common proficiency standard and resources benchmarks. This
study is one of first systematic attempts to link NAEP to other national data, including CCD F-33 and SASS, for an integrated analysis of those separate school input and student outcome data sources. This approach enabled me to examine racial and socioeconomic gaps in the joint distributions of mathematics achievement and school/teacher resources simultaneously from equity and adequacy perspectives. On one hand, I found significantly large mathematics achievement gaps among racial and socioeconomic groups. I found relatively small but significant degrees of gaps as far as racial and socioeconomic disparities in school funding and teacher qualifications are concerned. On the other hand, the percentages of students meeting the mathematics proficiency standard as well as corresponding benchmarks of school funding and in-field teaching were very low, regardless of race and poverty status, which implies common shortage of educational resources and support for meeting high standard across all student groups. Relative gaps compared with nonpoor or White counterparts were about a quarter of absolute gaps against desired standards and benchmarks. This does not mean that the inequalities of school learning are easy to address, as the goal is to ensure adequate performance for all without lowering the achievement of the higher performing group to close the relative gap.

Given systematically positive relationships between key school/teacher resources and student mathematics achievement, I estimated minimally adequate levels of current expenditures per pupil ($7,197 in year 2000 dollars) and in-field mathematics teaching rate for middle grades (91%) for students in an average district or school in the nation to reach the NAEP Grade 8 mathematics proficiency standard. Based on these estimates, filling the gap between these desired levels and present levels would require approximately an 11% increase in school funding and an 85% increase in in-field teaching. Adding up these extra costs for all public elementary and secondary school students (about 47 million students as of 1999–2000) across the nation would result in total extra cost of $33 billion (equivalent to 10% of total public school revenues). This overall estimation of extra funding considers only increases in current expenditures without consideration of in-field teaching factor. It is difficult to predict how much it will cost to raise in-field teaching rate across all middle and high school grades because the out-of-field teaching is more prevalent in the middle grades compared with the high school grades, and the present shortage of qualified teachers is attributable to teacher supply and demand factors (see Ingersoll, 1999, 2004). Moreover, these minimally adequate educational cost estimates would rise further for districts with many low-income minority students with greater educational needs and potentially higher costs.

Although federal funding for public education still makes up less than 10% of total educational spending, the role of federal government for developing and monitoring educational standards across the nation has increased under NCLB. The findings of the present study demand that educational policymakers become fully aware of unrealistically high expectations for schools, particularly ones with predominantly low-income minority students with greater needs for extra resources and support. At the same time, it is crucial for such schools to use resources more effectively by seeking evidence-based best practices. This will help strengthen the connection between school resources and student performance so that increased school funding and teacher qualification can be better translated into achievement results. The estimates of adequacy are based on the present technology of education and simply allocating more funding and qualified teachers to ineffective schools would not guarantee their academic success. More cost-effective strategies for improving chronically low-achieving schools with predominantly disadvantaged minority students are needed.

This study also has implications for redesigning the present NAEP data and nation’s report card to inform educational policy and practice for closing the achievement gaps. Using the NAEP data alone for national education report card presents limitations. One problem is that the data relied solely on school input or contextual variables available through limited survey questionnaires in NAEP. This study demonstrates utilities in linking NAEP to other national education databases that contain richer information on school funding and teacher qualification. The addition of SASS and F-33 data to NAEP can provide critical information on the adequacy of such key resources that are not presently directly available through NAEP.

However, the study also reveals technical difficulties and analytical challenges that prevent wide applications of such practices. Several recommendations are in order. First, common school district ID and school ID variables for merging different data sets must be readily available. Second, the overlap sample between the NAEP and other data sets must be designed carefully: The size should be sufficiently large for statistical power, and the selection process of overlapping schools or districts should involve stratified random sampling for adequate representation of the target population. For example, the NAEP-SASS link may be expanded so that the analysis of merged data can be done at the state and national levels. Last, an outstanding issue in merging NAEP with other national data sets is how to handle discrepancy in the grade levels of their samples. If it is assumed that the NAEP eighth-grade students’ achievement results from school effects throughout their K–8 education experiences, an adequate explanation of how school resources affect student achievement must postulate a mechanism that incorporates these cumulative influences. The qualities of present teachers and other resources available at a particular grade are not sufficient in explaining the historical and cumulative nature of student achievements. Particularly, the addition of information on and control for students’ mobility across schools and districts can enhance the inferences about the relationship between resources and achievement. Although the present policy efforts of building statewide longitudinal student tracking system would help address this issue (Data Quality Campaign, 2009), it remains a challenge.
to track students beyond the boundaries of states and link state-specific data to national data based on common standards.

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NOTES

1. Obviously disadvantaged groups of students are more expensive to educate but presently there are no national standards for determining the cost of educating different student groups. One common practice in school funding formula involves adjusting full student enrollment by weighting poor students by 1.4, special education students by 2.3, and LEP students by 1.2.

2. The “geographic cost-of-education index” as developed by Chambers (1998) was used (see http://www.nces.ed.gov/edfin/prodsurv/data.asp).

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AUTHOR NOTE
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