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Is National Board Certification An Effective Signal of Teacher Quality?

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Abstract

Many states and districts are moving toward more targeted compensation policies as a way to attract higher quality candidates into the teaching profession and to encourage increases in productivity among current teachers. Rather than align pay increases only to level of education and years of experience, for example, many school systems have started to tie pay increases or bonuses to National Board Certification (NBC). But the practice has been questioned, in part because of a lack of empirical evidence that NBC is an effective signal of teaching quality. The present study uses data from a large urban school district to examine the association between student gains in mathematics in the ninth and tenth grades, NBC, and other indicators of teacher quality. Based on a variety of different specifications and student subsamples, we find robust evidence that NBC is an effective indicator of teacher quality.

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Executive Summary

Although there is general agreement among policy-makers, educators, and researchers that teacher quality is key to student success, there is less agreement about the contribution that specific professional attributes make to good teaching. These paper exams nearly 108,000 individual student records collected from Miami-Dade County Public Schools to assess the contribution that teachers' professional characteristics make to student achievement in mathematics in the ninth and tenth grades. Each student record was linked to his or her subject-area teacher to create a rich data set containing information on teacher characteristics, student background and behavior, and school environment. Student gains were then examined in school years 1999-2000 to 2002-2003. Teacher characteristics that were considered in the models include:

- Whether the teacher is new or experienced
- Whether the teacher has a regular state certification in high school mathematics or middle school mathematics
- Whether the teacher holds a teaching position in mathematics or has another primary job assignment
- Whether the teacher has an advanced degree
- The selectivity of the teacher's undergraduate school
- Whether the teacher has National Board Certification (NBC), a pending application, or failed or withdrew from the program.

One of the strengths of the present data set is the detail we have regarding each of the ninth and tenth grade students that comprise our sample. In addition to standard demographic indicators, we are able to control for a number of indicators of student motivation and performance that may influence student gains on the end-of-year exams in mathematics. These include:

- Whether the student is repeating the current grade level
- Whether the student is identified as "gifted "
- Whether the student had an out-of school suspension in the current year
- The number of days the student was absent in the current year
- The student's grade point average in core subjects (mathematics, science, language arts, and social studies) in the current year
- The average teacher-assigned score over each marking period of the student's effort in mathematics class
- The average teacher-assigned score over each marking period for conduct in mathematics class
- The student's age
- The student's grade level
- Whether the mathematics class taken was above or below the student's grade level
- Whether the student was enrolled in a limited-English proficiency program in the current year or in the previous 2 years.

Findings

With the exception of undergraduate school quality, which can be interpreted as an indicator of the academic ability of the teacher (a factor often associated with student success), each of the teacher quality indicators made a correctly signed and statistically significant contribution to student outcomes.[2] When compared with students whose teachers had never been involved with NBC, we found that

[2] The coefficient for failure or withdrawal from the NBC process was significant only at the 10 percent level. All other factors were significant at conventional levels.

students with otherwise similar teachers made larger gains if their teacher had a NBC and smaller gains if their teacher failed or withdrew from the NBC accreditation process.

Keeping in mind that teachers bring bundles of characteristics to their classrooms and that those characteristics are correlated with one another, it is useful to compare predicted outcomes for students who have teachers with different professional profiles. After taking into account differences in the characteristics of their students, such comparisons show that students who had a typical NBC teacher made the greatest gains, exceeding gains of those with similar teachers who had failed NBC or had never been involved in the process. Students with new teachers who lacked a regular state certification, and those who had teachers whose primary job assignment was not mathematics instruction made the smallest gains.

Conclusions

In this study, NBC proved to be an effective signal of teacher quality. Indeed, seven of nine indicators of teacher quality that were included in the analyses resulted in appropriately signed and statistically significant evidence of their influence on student outcomes. Among those indicators, having an in-subject-area teacher, NBC and regular state certification in high school mathematics had the greatest effects.

These findings suggest that school systems that wish to target pay increases to teachers of the highest quality can use NBC for this purpose. Such a strategy will benefit students in the long term if NBC has the desired effect of attracting better candidates into teaching through incentives that are targeted to top performers or by and raising the professionalism and prestige associated with teaching. To increase student outcomes in the nearer term, the challenge for school systems will be to implement professional development programs or strategies that change practices so more teachers will adopt methods used by those who have already earned a NBC.

I. Introduction

Recent federal legislation has put increased pressure on school systems to staff all classrooms with "highly qualified" teachers and has focused attention on the importance of teacher quality for improving outcomes for students in kindergarten through twelfth grade (K-12). Prescriptions for improving the quality of the K-12 teacher workforce focus on instructional practices and/or market incentives. Those emphasizing instructional practices point to the need for improvements in the quality and alignment of preservice programs and inservice professional development, with state and national standards for K-12 course content and pedagogy. Those that focus more heavily on labor markets for teachers argue for the need to increase incentives to attract and retain high-quality teachers and to encourage teachers to strive continually to increase the performance of their students.

Pay-for-performance plans fall into this latter camp. A key goal of pay-for-performance strategies is to raise student outcomes by targeting pay increases (or bonuses) to teachers whose students outperform expectations. In practice, such systems are not completely reliant on performance indicators for setting salaries but are, to a greater or lesser extent, additions to traditional pay systems that set salaries based on years of experience and highest academic degree achieved (Milanowski, 2002). By targeting pay increases to teachers who demonstrate superior performance, the thinking is that school systems will create conditions that will encourage current teachers to make greater efforts to help their students succeed.

Research by Lavy (2004) and Kenny (2003) offers some support for this contention. Moreover, pay-for-performance systems may encourage top performers to stay in teaching, and may attract more of those with the potential to be top performers to enter the profession (2004b). Indeed, the general decline in relative earnings of teachers over time may help to explain the observed decrease, in national data, in the share of teachers with the greatest potential to help students learn (Flyer & Rosen, 1997), (Corcoran, Evans, and Schwab, 2004)

Another innovation, which some 30 states and scores of districts have adopted, is to offer financial incentives, usually as bonuses over several years, to teachers who earn certification from The National Board of Professional Teaching Standards (NBPTS).[3] NBC is voluntary and open to teachers with 3 or more years of experience. Teachers who earn NBC have successfully gone through a rigorous, standards-based assessment process to affirm their knowledge of content and pedagogy, use of high-quality instructional practices, and involvement in professional activities (2004a).

The first generation of standards and assessments took almost 5 years to develop and was used to evaluate applicants who sought board certification between 1996 and 2001. As data accumulated from early assessments, and interest in board certification grew, NBPTS worked with the Education and Testing Service to streamline the assessment process, while ensuring that certification would be consistent with earlier NBC decisions. The revised process remains a rigorous one. Applicants for NBC must prepare a portfolio with three classroom-based entries and a combined Document Accomplishment Entry that describes work with families and caregivers, as well as participation in the professional community. In addition, each applicant must complete six 30-minute exercises at the National Board's Assessment Center. The standards themselves are widely accepted in the education community and, since their introduction, have led to a realignment of standards by other accrediting agencies.[4]

Despite the use of authentic assessments, and the pedigree of NBPTS standards, empirical evidence of the effectiveness of NBC teachers to raise student achievement is limited. In an early analysis of NBC teachers, Lloyd Bond and his associates (2000) compared student writing samples for 31 teachers with NBC and 34 teachers

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[3] http://www.nbpts.org/about/images/stateincen_sup.table.pdf (October, 2004).

[4] The National Council for Accreditation of Teacher Education (NCATE) and the Interstate New Teacher Assessment and Support Consortium (INSTASC) have realigned their standards with NBPTS (Gordon, 2002).

who failed certification. They concluded that students taught by NBC teachers outperformed the other group in most dimensions. Although the researchers set up complex rubrics to judge student outcomes, they failed to control for factors other than NBC that could influence those outcomes. This omission will bias findings in favor of NBC teachers if, on average, more able students are assigned to these teachers, or if they are the most able teachers for other unmeasured reasons.

Recent studies have taken advantage of standardized exams to examine the relationship between the NBC status of teachers and their students' achievement. Stone (2002) used data from Tennessee's Value-Added Assessment System to estimate the effect of 16 NBC teachers in grades three through eight on average student gains in up to three subject areas. He concluded that the NBC teachers were only average producers of student achievement, but his study did not report traditional tests of statistical significance.

Two more-recent papers provide evidence of a positive relationship between NBC and student outcomes on standardized exams. In an unpublished paper, Goldhaber and Anthony (2004) used data from North Carolina for elementary students in the third, fourth, and fifth grades. They examined data for school years 1996-1997 through 1998-1999 in a multivariate analysis that estimated the effects of NBC on student gains on the state's end-of-grade exams in mathematics and reading. In most specifications of the models, they found a positive and significant effect for students who had teachers with NBC, or teachers who would become NBC teachers in the future. The results led the authors to conclude that the NBPTS process is an effective signal for identifying highly qualified teachers.

Most recently, Vandevoort and her associates (2004) reported results from a study of outcomes in reading, language arts and mathematics for elementary students in 14 Arizona school districts. They analyzed data from 35 classrooms with NBC teachers and their non-certified colleagues. In three-quarters of the 48 comparisons, the students of NBC teachers outperformed their counterparts. Results were statistically significant in one-third of those cases. However, the analyses did not take into consideration differences in student attributes that may correlate with NBC.

This paper adds to the empirical literature on teacher quality and student outcomes, paying particular attention to the relative outcomes of students who are instructed by teachers with NBC. Using a multivariate framework that takes into account differences in teacher, student, and school attributes, the paper considers evidence on the following issues

- Whether students who had teachers with NBC had larger achievement gains in mathematics in the ninth and tenth grades than their counterparts without such teachers
- Whether students who had teachers who failed, withdrew, or are applicants for NBC had larger achievement gains than their counterparts without such teachers
- All else equal, how the size of student gains associated with several teacher quality indicators compare with one another
- Whether the size of gains associated with NBC varies across different student subpopulations.

In contrast to work by prior researchers, the present study focuses on high school students. In addition, the teachers in the present study received their NBC through the more streamlined process that is currently being used by the NBPTS. We used individual student records linked to subject-area teachers for school years 2001, 2002, and 2003 for ninth graders and 2002 and 2003 for tenth graders. We found that all else equal, students with NBC teachers made larger gains in mathematics, on average, than did their counterparts without such teachers. In addition, the data reveal that students with teachers who were current applicants for NBC made larger gains than did their counterparts without such teachers, although these gains were smaller than those associated with NBC teachers. In contrast, students with teachers who failed or withdrew from the NBC application process made no such gains. Taken as a whole, the study's findings strongly support the view that NBC succeeds in identifying highly effective teachers.

Section II provides some background on NBC and describes the incentives available to teachers in this sample for earning certification. Section III describes the model and analytic approach, and section

IV describes the data. Findings are presented in section V, and section VI concludes.

II. Background

The NBPTS was founded in 1987 to "establish high and rigorous standards of what accomplished teachers know and should be able to do…" By January 2004, over 32,000 teachers had earned NBC. At a cost of $2,300 per applicant, this represents a combined investment of almost $74 million in application fees, which are frequently paid by state education agencies. In addition, the National Science Foundation and the U.S. Department of Education invested $109.3 million, or 51 percent, of the project's initial costs. Remaining start-up funds came from non-governmental sources, including private foundations.[5] In addition to these expenditures, many states and districts are offering teachers who earn NBC bonuses or salary premiums.

In the state of Florida, where we draw data for the present study, 90 percent of the application fee is paid by the state. In addition, the state provides $150 to help teachers defray costs associated with preparation of the portfolio. Teachers whose applications are successful earn substantial pay increases—10 percent of the previous year's statewide average salary for classroom teachers for the 10-year life of the certificate. NBC teachers in Florida may earn an extra 10-percent increase if they agree to provide the equivalent of an additional 12 workdays of mentoring or related services to teachers who do not hold NBC.[6]

Teachers who work in Miami-Dade County Public Schools also receive a one-time stipend of $5,000 after completing 3 years of service following certification. In addition, all applicants can receive up to 120 Master Points for going through the NBPTS process, or the equivalent of their professional development requirements for renewal of their state certification. These incentives have led increas-

[5] Research Related to the National Board for Professional Teaching Standards, Request for Proposals, January 2002.

[6] www.nbpts.or/aboput/stateinfo.cfm?state=Florida, 9/17/2004.

ing numbers of teachers to seek National Board Certfication, providing a valuable data set for analysis of the effectiveness of such teachers.

III. The Model and Analytic Approach

We estimate a model of the following form, where subscripts *i, j, s,* and *t* denote the student, teacher, school, and year respectively.

$$\text{SCORE}_{ijst} = f(\text{SCORE}_{ijs(t-1)}, \text{STU}_{ijst}, \text{NBC}_{ijst}, Z_{ijst}) + e_{ijst.}$$

In this traditional production-function formulation, each student's score on the state's end-of-grade exam in mathematics (SCORE_{ijst}) is modeled as dependent on his or her score in the previous year. Because the tests are aligned across grade levels and over time, these developmental scale scores can be used to measure the growth in achievement of individual students over time.

STU_{ijst} is a vector of student characteristics. This vector is important because it captures differences in the background characteristics and behaviors of individual students that can have an independent effect on student achievement. Without such a vector, student gains could be inappropriately ascribed to differences in teacher attributes that correlate with these characteristics. If students who are likely to make greater gains on the state end-of-grade exams are assigned to teachers with more experience, or better credentials, then such omissions would overstate estimates of the contribution that measured teacher attributes make to student achievement.

The rich set of information on students is one of the strengths of the present data set. In addition to standard demographic indicators, we control for a number of indicators of student motivation that may influence student gains on the end-of-year exams in mathematics. These include:

- Whether the student is repeating the current grade (retained)
- Whether the student is gifted

- Whether the student had an out-of school suspension in the current school year
- The number of days the student was absent in the current school year
- The student's unweighted grade point average in core subjects (mathematics, science, language arts and social studies) in the current school year
- The average teacher-assigned score over each marking period of the student's effort in mathematics class in the current school year
- The average teacher-assigned score over each marking period for conduct in mathematics class in the current school year.
- The student's age in years
- The student's grade level
- Whether the mathematics class taken in the current school year was above or below grade level
- Whether the student was enrolled in a limited-English proficiency program in the previous 2 years.

NBC_{jst} is a vector of teacher variables that denote involvement with NBC. The NBPTS announces outcomes for applicants in late November of each year. We consider a teacher who becomes certified during a given school year to be certified for that year and all subsequent school years. In addition, we control for whether a teacher ever failed NBC or withdrew early from the program, and whether a teacher has an application pending. Teachers who have never been involved in the NBC process are the control group to which outcomes for each NBC status are compared.

Because current applicants are made up of a mix of teachers who will subsequently pass, withdraw, or fail NBC, the average effect of current applicants on student outcomes is a weighted average of the separate effects on student outcomes of such teachers. In the steady state therefore, its estimated effect should fall somewhere between the others, if the NBC process is a consistent one. The variable is of further interest because it can tell us about the average quality of

the applicant pool. Similarly, it is of interest to determine whether teachers who have failed or withdrawn from the certification process differ systematically from nonapplicants, or from those who ultimately earned NBC. If NBPTS has developed a useful mechanism for identifying teachers whose professional knowledge and practices reflect "what an experienced teacher should know and be able to do," and if such practices affect student outcomes, then we should expect to see systematic differences in estimated effects on student outcomes among NBC teachers and other teacher subpopulations.[7]

Z_{jst} is a vector of additional control variables accounting for teacher and school characteristics and school year. Teacher attributes that we control for include:

- Whether the teacher has a regular state certification in high school mathematics or middle school mathematics
- Whether the student's mathematics teacher holds a teaching position in mathematics or has another primary job assignment
- Whether the teacher is inexperienced, as indicated by placement in salary schedule at pay step 1 or 2
- Whether the teacher has a graduate degree
- The selectivity of each teacher's undergraduate institution, based on a 1 to 5 scale, where 1 is considered most competitive, according to *Peterson's Guide to 4-Year Colleges and Universities*. Approximately one quarter of ninth and tenth grade mathematics teachers in the district earned degrees from institutions that were not included in *Peterson's Guides*.[8] For those teachers, we assigned the mean value for reporting teachers in our sample

[7] In districts where all teachers meet the standards of quality described by NBPTS, we would not expect to see NBPTS failures, or statistically significant differences in student outcomes between NBC teachers and others. In such a case, the licensing process could be accurate, but adds no information about teacher quality.

[8] In some cases, the undergraduate institution may have been ambiguous (for example, when a state university system rather than a specific

- A dummy variable for teachers who came from an unrated school. We included in our models an interaction term between selectivity and those with a constructed value. This variable allows us to adjust the estimated influence on student outcomes of undergraduate school quality for unrated schools.
- Two school year variables, SY02 and SY03. These variables capture upward shifts in scores on the end-of-year exams in mathematics that are present in the data.

Teachers in Miami-Dade County Public Schools receive an initial school assignment which they must retain for 3 years. Although the initial assignment could be random, work in New York City schools by Lankford, Hamilton. Loeb, and Wyckoff (2002) suggests that teacher sorting begins with the first teaching assignment. In addition, after 3 years, teachers who remain in the district may seek to change their school assignment. Because school environment may have an independent effect on student gains, as well as teacher assignments, it is important to take such factors into consideration when interpreting the measured effects of teacher attributes on student outcomes. Several school context variables are introduced in various specifications of the model, including:

- Total number of reported incidents of crime and violence in school year *t*
- Percentage of students absent for 21 days or more in school year *t*
- Student mobility (percentage of students enrolled in October who are remaining in February)
- Per pupil spending for regular students in year *t*
- Percentage of school staff who are administrators
- School size (enrollment).

campus was identified in the teacher record) or is missing. When missing, the school of record was frequently a foreign or religious institution.

In the analyses that follow, the baseline model includes only student and teacher attributes. The second model includes school attributes. This specification can be expected to reduce the estimated effects of individual teacher characteristics on student outcomes, if teachers with better credentials are more likely to be assigned to schools with better learning environments. In the third model, we replace observable school attributes with school fixed effects. Although models 2 and 3 have the advantage of netting-out school effects from estimates of teacher effects, they could lead to underestimates of the effectiveness associated with teacher attributes. This would be the case, for example, if positive teacher attributes work not only to directly improve student outcomes, but also work indirectly by raising the average quality of the learning environment in the schools in which these teachers work.[9]

Nevertheless, even models 2 and 3 could overstate teacher contributions to student outcomes if unobserved within-student differences that correlate with teacher assignment and student learning are unaccounted for in the model. Ultimately, we will present estimates from a student fixed-effects model to accommodate this possibility. However, these models must be interpreted cautiously because they rely on only two observations per student.

IV. The Data

Data for this study come primarily from three separate administrative offices within the school district. The Office of Assessment and Data Analysis furnished four snapshots of individual student records for grades six through twelve, covering school years 1999-2000 to 2002-2003 (SY00 to SY03). Each record includes a student identifier and standard demographic information. For each of four core courses in mathematics, science, social studies and language arts, the data set also includes a course identifier, a course-specific teacher ID, and student performance data, including mid-

[9] Better teachers could raise the average quality of instruction in a given school in a number of different ways. For example, such teachers might take a team approach to student learning, professional mentoring, and problem solving, thereby raising average outcomes in the school.

term and final grade, and quarterly conduct and effort grades. We use these data to construct a set of indicators of student motivation and performance. In addition, we use information in the data set on the number of absences in the school year, and the number of outdoor suspensions over the school year.

The Office of Human Resources provided us with annual December snapshots of the workforce for the district. These files include an employee ID number that we use to match teacher attributes with student records. The personnel demographic files include information on each teacher's age, gender, ethnicity, and degrees earned. For teachers with an education major, or an education-related major only we know the field of study (for example, mathematics-education). The data also include the schools from which the undergraduate and graduate degrees were earned.

The Office for Professional Development provided a file with all teachers in the district who had had some involvement with the NBPTS process as of March 2003. The file includes teacher ID number, current NBPTS status, initial date of status, and field of certification or application. Over the period from 1999 to March 2003, 1,795 teachers were recorded as having some involvement with the NBPTS. Of those, 973 had pending applications, 387 had either failed or withdrawn from the process, and 435 teachers had earned NBC. The district's NBC teachers are certified in 22 different areas, with the largest concentrations in Middle Childhood/Generalist (17 percent), Early Childhood through Young Adult/ Special Needs (16 percent) and Early Childhood Generalist (11 percent). An additional 38 percent of NBC teachers have certifications in the core academic areas of mathematics, science, English/language arts, or social studies.

For this study, we focus on ninth grade students who took the state end-of-grade exam in mathematics in school years 2001-2003, and tenth grade students who took the end-of-grade exam in school years 2002 or 2003.[10] As can be seen in table 1, NBC teachers in-

[10] The state did not give an end-of-grade exam to ninth graders in 2000. As a result, only tenth graders who were retained in 2000 had a prior-exam score in 2001.

structed 3,049 students, or 2.8 percent of the sample, over the period of our study. An additional 4,749 students (4.4 percent of the sample) were instructed by NBPTS applicants; 1,409 students had teachers who either failed certification (662), or withdrew from the process (747).

Table 1. Composition of the Sample

Student Records by NBPTS Status of Teacher and Year

School year	NBC	Applicant	Fail/WD	Non-NBPTS	Total
2001	254	852	0	18346	19452
2002	1308	1970	436	40655	44369
2003	1487	1916	973	39800	44176
Total	3049	4738	1409	98801	107997

Teacher Years by NBPTS Status and Grade Level

Grade level	NBC	Applicant	Fail	Withdrawn	Non-NBPTS
9th only	12	43	0	3	717
9th & 10th	38	53	8	7	1101
10th only	11	5	0	0	129
Total	61	101	8	10	1947

For school-level indicators of the teaching and learning environment, we extracted information from publicly available data sets posted on the state Department of Education's website. The Florida Schools Indicators Reports include information on enrollments, finances, school safety, absenteeism, and a number of other measures. These data had to be cleaned to eliminate records with missing information that had been recorded as zero.[11] Once the data were cleaned, we used those variables that had complete records for the schools that make up our sample.

Table 2 presents summary statistics for the sample. The first five data columns display variable means and standard deviations by NBPTS status. Overall statistics for the sample are presented in the last column. Whereas NBC teachers have higher post-test scores than other groups, their students' gains differ little from those of

[11] Schools with no information reported, for example, had zeros recorded for all variables. In other cases, zeros were recorded when a category did not apply, for example, the high school graduation rate for a middle school.

other teachers. There are some notable differences in the characteristics of the students of NBC teachers, however. Students with teachers who passed or failed NBPTS have different demographics than students of other teachers. In particular, students with NBC teachers, or teachers who failed certification, are less likely to be Black than are students of teachers who have never been involved in the NBPTS process, or who have pending or withdrawn applications (11 to 14 percent, versus 28 to 30 percent). Instead, students of NBC teachers, and teachers who failed certification, are more likely to be white or Hispanic. In addition, students of NBC teachers, and of teachers who failed NBC, are less likely to be reported as eligible for free or reduced-price lunch than others. Moreover, students of NBC teachers are far more likely to be considered gifted (24 percent), in comparison to students in all other groups (6 percent). In addition, students of NBC teachers are less likely to have had an out-of-school suspension during the school year, have fewer absences, are less likely to be repeating the current grade level, and have higher GPAs as measured by end-of-year grades in current year core courses.

Table 2. Means and Standard deviations for the sample by NBPTS Status of Teacher

Variable	Certified	With-drawn	Fail	Applicant	Not In-volved	Total
Test Scores						
Post-test score	2016.84	1880.43	1945.64	1885.43	1856.55	1863.05
	(182.446)	(210.718)	(188.363)	(216.468)	(215.267)	(216.067)
Prior test score	1950.14	1814.49	1894.43	1824.46	1791.09	1797.84
	(208.547)	(223.979)	(213.950)	(235.710)	(231.295)	(232.422)
Gain	66.70	65.94	51.21	60.97	65.45	65.21
Student Attributes						
Black	0.14	0.28	0.11	0.29	0.30	0.29
	(0.350)	(0.450)	(0.312)	(0.455)	(0.458)	(0.456)
Hispanic	0.67	0.59	0.69	0.55	0.57	0.57
	(0.472)	(0.492)	(0.463)	(0.498)	(0.495)	(0.495)
White/other	0.19	0.13	0.20	0.16	0.13	0.13
	(0.393)	(0.332)	(0.402)	(0.365)	(0.337)	(0.340)
Male	0.48	0.46	0.46	0.48	0.50	0.50
	(0.500)	(0.499)	(0.499)	(0.499)	(0.500)	(0.500)
Free/reduced price lunch	0.35	0.51	0.35	0.46	0.45	0.45
	(0.477)	(0.500)	(0.477)	(0.498)	(0.497)	(0.497)
Gifted student	0.24	0.05	0.06	0.06	0.06	0.07
	(0.425)	(0.211)	(0.247)	(0.236)	(0.245)	(0.253)
Ever suspended	0.04	0.10	0.05	0.10	0.11	0.10
	(0.184)	(0.295)	(0.221)	(0.299)	(0.309)	(0.305)
Days absent	7.32	9.87	7.40	10.31	10.90	10.74
	(7.783)	(10.177)	(7.150)	(10.729)	(10.961)	(10.869)
Retained	0.04	0.08	0.05	0.05	0.07	0.07
	(0.202)	(0.272)	(0.208)	(0.227)	(0.258)	(0.255)
GPA	2.24	1.99	2.34	2.00	1.90	1.92
	(1.003)	(1.039)	(0.970)	(1.002)	(0.977)	(0.981)
Grade 10	0.45	0.37	0.25	0.34	0.37	0.37
	(0.498)	(0.483)	(0.435)	(0.475)	(0.482)	(0.482)
Math effort	1.66	1.81	1.50	1.85	1.87	1.86
1=Outstanding	(0.646)	(0.670)	(0.554)	(0.670)	(0.642)	(0.645)
Math conduct	3.50	3.37	3.42	3.30	3.16	3.17
4=A	(0.736)	(0.863)	(0.739)	(0.889)	(0.923)	(0.918)
Age	16.05	16.00	15.83	16.01	16.06	16.06
	(0.727)	(0.683)	(0.718)	(0.760)	(0.794)	(0.790)
Exceptional student	0.03	0.01	0.15	0.12	0.10	0.09
	(0.174)	(0.115)	(0.357)	(0.322)	(0.293)	(0.292)
English language learner	0.05	0.13	0.03	0.04	0.07	0.07
	(0.210)	(0.335)	(0.179)	(0.206)	(0.261)	(0.257)
ELL in past 2 years	0.46	0.44	0.50	0.44	0.45	0.45
	(0.499)	(0.497)	(0.500)	(0.496)	(0.497)	(0.497)

Table 2. Means and Standard deviations for the sample by NBPTS Status of Teacher (cont., 2)

	Certified	With-drawn	Fail	Applicant	Not In-volved	Total
Below grade	0.15	0.04	0.11	0.08	0.09	0.09
	(0.352)	(0.200)	(0.319)	(0.275)	(0.283)	(0.285)
Above grade	0.25	0.16	0.11	0.19	0.15	0.15
	(0.432)	(0.362)	(0.308)	(0.391)	(0.354)	(0.358)
Teacher Attributes						
Years experience	16.72	13.37	12.96	13.80	13.37	13.48
	(5.415)	(6.345)	(3.988)	(6.242)	(8.958)	(8.754)
Graduate degree	0.45	0.06	0.35	0.36	0.23	0.25
	(0.497)	(0.241)	(0.477)	(0.481)	(0.423)	(0.430)
Teacher in subject area	0.96	0.86	0.86	0.85	0.87	0.87
	(0.204)	(0.346)	(0.351)	(0.354)	(0.336)	(0.334)
Salary step 1 or 2	0.00	0.00	0.00	0.00	0.03	0.02
	(0.000)	(0.000)	(0.000)	(0.000)	(0.159)	(0.153)
Undergrad selectivity	2.88	2.86	2.99	2.80	2.99	2.98
1=Most competitive	(0.304)	(0.478)	(0.018)	(0.445)	(0.567)	(0.556)
Constructed*selectivity	0.93	1.06	0.85	0.83	0.70	0.72
	(1.373)	(1.420)	(1.340)	(1.332)	(1.259)	(1.269)
State Certified HS math	0.98	0.90	0.86	0.76	0.61	0.63
	(0.149)	(0.301)	(0.351)	(0.424)	(0.488)	(0.483)
State Certified MS math	0.06	0.50	0.00	0.25	0.22	0.22
	(0.231)	(0.500)	(0.000)	(0.434)	(0.417)	(0.415)
State Certified either	0.98	1.00	0.86	0.90	0.78	0.79
	(0.140)	(0.000)	(0.351)	(0.300)	(0.417)	(0.407)
School Attributes						
Enrollment	3232.30	3593.90	3584.54	2998.43	3281.16	3271.40
	(1133.46)	(966.275)	(781.822)	(1245.93)	(853.248)	(886.171)
Per pupil expenditures	4630	4576.65	4137.99	4869.17	4528.93	4544.65
	(1410)	(1332)	(453)	(1518)	(838)	(905)
Percent administrators	2.34	2.50	2.19	2.45	2.40	2.40
	(0.422)	(0.599)	(0.157)	(0.548)	(0.392)	(0.402)
Student mobility	92.93	91.84	94.77	92.86	92.16	92.23
	(2.423)	(2.195)	(2.447)	(3.534)	(2.599)	(2.654)
Pct absent 21+ days	10.41	17.68	9.29	16.76	17.97	17.65
	(5.227)	(4.789)	(4.870)	(9.700)	(8.718)	(8.762)
n acts crime or violence	180.70	257.45	145.32	218.19	227.74	225.69
	(102.110)	(106.956)	(45.840)	(102.335)	(85.608)	(87.523)
School year 2001	0.08	0.00	0.00	0.18	0.19	0.18
	(0.276)	(0.000)	(0.000)	(0.384)	(0.389)	(0.384)
School year 2002	0.43	0.26	0.37	0.42	0.41	0.41
	(0.495)	(0.437)	(0.483)	(0.493)	(0.492)	(0.492)
School year 2003	0.49	0.74	0.63	0.40	0.40	0.41
	(0.500)	(0.437)	(0.483)	(0.491)	(0.490)	(0.492)
n of observations	3049	747	662	4738	98801	107997

These differences suggest that students and teachers are not randomly paired, but that more academically successful students are more likely to be paired with more highly qualified teachers. A variety of factors may be operating to cause these differences, including the assignment of more effective teachers to better schools, and the systematic assignment of teachers and students to specific mathematics courses. At the same time, the high share of gifted students who are instructed by NBC teachers may suggest that the NBC process itself favors teachers with such students. This would be the case, for example, if teachers of gifted students have greater opportunities to use teaching methods, and to create student assignments that are consistent with those described in NBPTS standards or assessments.

The second part of table 2 displays differences in other teacher quality indicators that students are more or less likely to encounter, depending on the NBPTS status of their teacher. In general, students who have a mathematics teacher who holds NBC, are also likely to have a teacher with more experience (16.7 years, versus 13.4 years for teachers who have not been involved in NBPTS) and a higher level of education than others (45 percent of NBC teachers hold an advanced degree, compared with 23 percent for teachers who have not been involved in NBPTS). Such a teacher is also somewhat more likely to have come from a more competitive college, to hold a regular state certification in mathematics (either high school or middle school), and to have a teaching position in mathematics. Although these attributes alone suggest that NBC teachers are highly qualified, it is also the case that in many empirical studies, years of experience and level of education are shown to be only weakly associated with improvements in student outcomes (Rivkin, Hanushek, and Kain, 2002). Moreover, it is an important empirical question to see if NBC does little more than assign a professional credential to teachers with other, already observable, indicators of teacher quality.[12]

[12] For a review of the teacher quality debate and related literature, see Barnett Berry, "Recruiting and Retaining "High Quality Teachers" for Hard to Staff Schools," NASSP Bulletin, Vol. 87, No. 638, March 2004.

Differences in the characteristics of schools that students attend by the NBPTS status of their teacher are reported in the bottom section of table 2. Students with NBC teachers attend schools that are similar to other schools in level of enrollments, share of administrators to total school staff, spending per regular student, and levels of student mobility. But those schools have better attendance records (10.4 percent of students missed 21 or more days on average, compared with 18 percent of students in schools where students had teachers that were not involved in NBPTS), and fewer total incidents of crime or violence (181 versus 228) in a given year. Controlling for these differences will help disentangle differences in student preparedness to learn and in school context that can affect student outcomes from differences in teacher contributions to learning.

V. Findings

Table 3 presents key results from the analysis of student achievement in mathematics in the ninth and tenth grades. Column 1 displays results from an OLS regression that includes student and teacher attributes and year fixed effects. The top section of the table displays the effects of student covariates on achievement. All of the covariates have the expected signs. Males make greater gains than females; traditionally underserved minorities make smaller gains than others. The negative Black effect is substantially larger in absolute value than the Hispanic effect. The effect associated with students who are eligible for free or reduced-price lunch is negative and significant, but only half as large as the Hispanic effect.[13] Student performance indicators that are normally unavailable to re-

[13] Because the number of students who are reported eligible for free or reduced-price lunch declines as grade level increases, we experimented with a broader indicator of economic hardship: eligibility for free or reduced-price lunch in the previous year. While this covariate has a larger mean, it had little impact on the size of the estimated effect on student outcomes, or on other measured effects. (Results are not shown, but are available from the author upon request.).

searchers, but that had a large, positive, and significant effect on outcomes, include student eligibility for gifted programs, current year GPA, high combined scores for in-class conduct and effort, and enrollment in an above-grade-level course in mathematics. Students enrolled in classes for English Language Learners (ELL) did more poorly than others, all else equal, but this disadvantage is one-sixth the size for former participants in such classes. After controlling for grade level, older students perform less well than others. In addition, all else equal, students in exceptional education programs perform substantially worse than others.

Table 3. Student Achievement in 9th and 10th grade Mathematics

	Model 1	Model 2	Model 3	Model 4	Model 5	Effect Size Model 3
Student Covariates						
Prior test score	0.529	0.517	0.509	0.529	0.509	0.548[a]
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Grade 10	59.116	59.350	60.743	59.078	60.725	0.281
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Male	31.386	32.321	32.790	31.412	32.800	0.152
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Black	-42.929	-35.319	-31.837	-43.390	-32.146	-0.147
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Hispanic	-15.064	-14.827	-10.396	-15.565	-10.749	-0.048
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
ELL	-36.615	-37.416	-40.777	-36.615	-40.773	-0.189
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
ELL prior	-5.922	-6.313	-7.365	-5.893	-7.368	-0.034
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
F/R lunch	-7.501	-4.572	-4.485	-7.482	-4.481	-0.021
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Retained	-4.087	-5.328	-5.362	-4.391	-5.708	-0.025
	(0.017) **	(0.002) ***	(0.002) ***	(0.011) **	(0.001) ***	
Gifted student	45.045	45.453	46.107	45.867	45.887	0.213
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	

Table 3. Student Achievement in 9th and 10th grade Mathematics, (cont.)

	Model 1	Model 2	Model 3	Model 4	Model 5	Effect Size Model 3
Ever suspended	-0.049	0.150	-1.199	-0.018	-1.179	-0.006
	(0.971)	(0.910)	(0.375)	(0.989)	(0.383)	
Days absent	-0.114	0.142	0.195	-0.114	0.195	0.011[a]
	(0.005) ***	(0.001) ***	(0.000) ***	(0.005) ***	(0.000) ***	
GPA	32.903	34.129	35.576	32.917	35.580	0.165
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Math effort	-9.461	-9.211	-8.758	-9.439	-8.765	-0.041
1=outstanding	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Math conduct	4.230	3.259	3.050	4.239	3.057	0.014
4=A	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Age	-13.092	-12.671	-13.319	-13.086	-13.319	-0.062
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Exceptional prog	-59.930	-64.490	-66.490	-59.965	-66.528	-0.308
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Above grade	21.378	21.916	24.319	21.361	24.347	0.113
	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	(0.000) ***	
Below grade	3.226	4.255	3.490	3.175	3.524	0.016
	(0.015) **	(0.001) ***	(0.008) ***	(0.017) **	(0.008) ***	
Teacher Covariates						
National Board						
certified	26.745	17.721	15.994	17.258	7.837	0.074
	(0.000) ***	(0.000) ***	(0.000) ***	(0.002) ***	(0.153)	
pending	5.119	4.176	4.152	5.112	4.094	0.019
	(0.005) ***	(0.021) **	(0.026) **	(0.005) ***	(0.028) **	
failed/withdrawn	-0.623	-5.284	-5.663	-0.610	-5.676	-0.026
	(0.848)	(0.103)	(0.084) *	(0.851)	(0.083) *	
NBC*black				15.218	7.997	
				(0.054) *	(0.308)	
NBC*Hispanic				13.880	8.578	
				(0.020) **	(0.147)	
NBC*retained				17.087	19.495	
				(0.119)	(0.072) *	

Table 3: Student Achievement in 9th and 10th grade Mathematics, (cont.)

	Model 1	Model 2	Model 3	Model 4	Model 5	Effect Size Model 3
NBC*F/R lunch				-1.228	-0.560	
				(0.790)	(0.903)	
NBC*gifted				-9.568	2.940	
				(0.082) *	(0.594)	
In subject area	26.181	24.187 ***	24.569 ***	26.224	24.573	0.114
	(0.000) ***	(0.000)	(0.000)	(0.000) ***	(0.000) ***	
salary step 1-2	-4.955	-9.290 ***	-10.698 ***	-4.981	-10.694	-0.050
	(0.047) **	(0.000)	(0.000)	(0.046) **	(0.000) ***	
state cert HS	12.451	13.370 ***	12.266 ***	12.364	12.261	0.057
	(0.000) ***	(0.000)	(0.000)	(0.000) ***	(0.000) ***	
state cert MS	4.141	5.832 ***	5.724 ***	4.106	5.728	0.027
	(0.000) ***	(0.000)	(0.000)	(0.000) ***	(0.000) ***	
Graduate degree	2.197	2.404 ***	3.578 ***	2.169	3.584	0.017
	(0.013) **	(0.007)	(0.000)	(0.015) **	(0.000) ***	
Undergrad selec	-2.823	-0.376	1.321 *	-2.861	1.320	-0.012[b]
1=most compet.	(0.000) ***	(0.577)	(0.054)	(0.000) ***	(0.055) *	
construct*selec	-1.932	-2.182 ***	-0.747 **	-1.893	-0.744	-0.007[b]
	(0.000) ***	(0.000)	(0.016)	(0.000) ***	(0.016) **	
SY 2002	3.832	3.820 ***	3.530 ***	3.871	3.557	0.016
	(0.001) ***	(0.001)	(0.002)	(0.001) ***	(0.001) ***	
SY 2003	27.826	27.640 ***	27.207 ***	27.819	27.215	0.126
	(0.000) ***	(0.000)	(0.000)	(0.000) ***	(0.000) ***	
School Attributes	No	Yes	No	No	No	No
School Fixed Effects	No	No	Yes	No	Yes	Yes
Adj R2	0.69	0.69	0.69	0.69	0.69	0.69
Sample size	107997	107997	107997	107997	107997	107997

P-values reported in parentheses.

a. Effect size is given by the estimated coefficient multiplied by (st dev x/st dev y). Unless otherwise noted, all other effect sizes are given by the ratio (coef/st dev y).

b. Effect size for 2-unit change in the competitiveness of the undergraduate institution. Note that expected achievement declines with increases in the selectivity of the undergraduate school in this specification of the model.

Effect of National Board Certification

The separate effects of teacher attributes on student outcomes are displayed in the lower half of table 3. The coefficient on NBC is large, positive, and significant at the 1-percent level. After accounting for all other observable indicators of teacher quality, the effect size for NBC, (given by the estimated coefficient divided by the standard deviation of the post-test score for the sample), is 0.12. In other words, students with NBC teachers gain 12 percent of a standard deviation more than others on the end-of-grade exam in mathematics, all else equal. The coefficient for pending applicants is also positive and significant, but it is about one-fifth the size of the coefficient for NBC teachers. The coefficient for students who had teachers who failed or withdrew from the certification process is small, negative, and statistically insignificant. These initial results support the view that NBC teachers are doing things that result in higher average gains for students. In addition, the NBPTS process successfully discriminates among applicants of varying quality.

Once school attributes are taken into consideration (model 2), or school fixed effects are included (model 3), the estimated effect size for an NBC teacher is estimated to be 0.07 to 0.08, all else equal. That is, students with NBC teachers are predicted to gain from 7 to 8 percent of a standard deviation more than they would have with otherwise similar non-NBC teachers. In models 2 and 3, the estimated effect remains significant at the 1-percent level. The smaller positive effect for students with teachers who are NBC applicants remains stable in magnitude and statistical significance, whereas the negative coefficient for failed/withdrawn becomes more negative and becomes significant at the 10-percent level of significance (p=.084). The results again provide evidence that the NBPTS process is an effective signal of teacher quality, as well as a valid discriminator among applicants.[14]

[14] In other specifications of the model, separate indicators were used for teachers who failed and teachers who withdrew from the NBPTS process. In these specifications, students who had teachers who had failed certification made smaller gains than students who had NBC teachers,

Next, the data were examined to determine whether the estimated benefits associated with having an NBC teacher vary across student subpopulations, beginning with a model that allowed the NBC effect to vary for Blacks, Hispanics, students who are eligible for free or reduced-price lunch, students who were retained in grade in the previous year, and students who are classified as gifted. In a model that considered only student and teacher attributes (model 4), we found that NBC teachers benefited Black and Hispanic students more than other students and about equally to one another. Moreover, the effect sizes were large (0.14 to 0.15) and statistically significant (p=.02 and .054 for Hispanics and Blacks, respectively). The estimated effect size for students who were retained in grade (0.16) suggests that they also may accrue substantially greater benefits than other students, but the estimate is imprecise and not significant at conventional levels. For students who are eligible for free or reduced-price lunch, the interaction effect is small in magnitude and statistically insignificant; they benefit about as much as others from having an NBC teacher. Gifted students, in contrast, made smaller gains than others with NBC teachers.

Model 5 incorporates school fixed effects in the prior model. As before, the inclusion of school fixed effects dampens the estimated effect of NBC, as well as the Black and Hispanic interaction terms. These coefficients also lose statistical significance. The coefficient for students who were retained in grade and had an NBC teacher remains large and becomes significant at the 10-percent level (p=.072), whereas the gifted effect shrinks in magnitude and statistical significance.

Although the correlations between the race/ethnic covariates and free/reduced lunch and retained covariates were small (not shown), we explored the possibility that including all of the interactions in a single model masked the size or importance of the NBC effect for these subpopulations. It did not. In alternative models, NBC teachers were never found to provide a unique advantage to

but greater gains than students who had teachers who withdrew. The findings are consistent with the notion that teachers who failed were near misses, and that teachers who withdrew recognized early on that they were unlikely to be successful applicants.

students who are eligible for free/reduced price lunch that exceeded the benefits to other students who had such teachers. Estimates of other interaction terms were similarly robust to the changes in specification.

Other Indicators of Teacher Quality

In this section, we return to our preferred model (model 3) to discuss estimated effect sizes for each of the indicators of teacher quality and to consider the combined impact of teacher quality indicators for several different teacher quality profiles. Recall that model 3 controls for nine teacher attributes as well as for school fixed effects and a wide range of student attributes and behaviors that can influence outcomes.

Seven of the nine teacher attributes are appropriately signed and statistically significant at conventional levels.[15] As shown in results column 6 of table 3, having a teacher in field has an estimated effect size of 0.11. Teachers with NBC have an effect size of 0.074 when compared to otherwise similar teachers. Students who have a teacher with a regular state certification in high school mathematics have an expected effect size gain of 0.057. In other words, this credential adds 5.7 percent of a standard deviation to test scores for otherwise identical students. Teachers in pay step 3 or above have an effect size of 0.05 when compared to similar teachers who are at pay step 1 or 2. Having a teacher with regular state certification in

[15] The coefficient for failed/withdraw was significant at the 10 percent level. The coefficient on college selectivity was small and incorrectly signed. Almost one quarter of our observations were missing data for this covariate, and used instead a constructed value. To determine if use of the constructed value caused the unexpected result, we reestimated the models dropping observations when the value was constructed. The new coefficient was properly signed in the baseline model, but not in the models that included teacher attributes or teacher fixed effects.

middle school mathematics or a graduate degree has smaller effects on student outcomes.[16]

Keeping in mind that teachers bring bundles of characteristics to classrooms, and that those characteristics are correlated with one another, it is useful to compare predicted outcomes for students who have teachers with different professional profiles. Using a typical board-certified teacher as a baseline, table 4 displays the predicted gains that students would make with such a teacher relative to several other professional profiles for teachers.[17] The effect size for a typical NBC teacher, compared to a similarly qualified teacher who failed or withdrew from the NBC process is 0.10. Next, we consider effect sizes when compared to new teachers with various other quality indicators: (a) teaching in subject area and hold a regular state certification in mathematics, (b) teaching in subject area but lacking a state certification, and (c) teaching out-of-subject area and lacking a regular state certification. The NBC effect sizes for these three teacher types are 0.13, 0.19, and 0.30 respectively.

[16] The smaller effect for state certification in middle school mathematics is not surprising, because these teachers are instructing high school classes. As discussed previously, the competitiveness of the undergraduate school had a different effect than what was expected. One possible explanation for this finding is that the local colleges that feed the school district have strong programs for aspiring teachers, but they are not highly competitive.

[17] We assume that the typical NBC teacher holds a state certification in high school mathematics, is teaching in the subject area, and has a 45 percent probability of holding an advanced degree.

Table 4. Effect Sizes for Typical NBC Teacher Compared with Other Teacher Profiles

Teacher Profile	Effect Size
Similar teacher who failed or withdrew from NBC	.10
New teacher, teaching in subject area, state certified in mathematics	.13
New teacher, teaching in subject area, lacking state certification	.19
New teacher, teaching out of subject area, lacking state certification	.30

Sensitivity Tests

We broke the full sample into subsamples to determine whether particular student subsamples were driving the results, or instead, if the results were robust across student subpopulations. Models 6 through 9, shown in table 5, display the effect sizes for each teacher quality indicator separately for ninth and tenth graders. NBC coefficients are positive and significant for both subsamples in models with and without school fixed effects. Models 10 through 13 display effect sizes for exceptional students and for regular and gifted students respectively. Although effect sizes vary across subsamples, in all but one case, the NBC coefficients are statistically significant. Although few exceptional students had NBC teachers (0.9 percent), the estimated effect sizes are large. Students with NBC teachers who receive special services scored substantially better than their counterparts (effect size 0.18 in school fixed effects model). Results for the regular and gifted students are similar to those found for the full sample of students (models 1 and 3).

Table 5: Effect Sizes for Teacher Quality Indicators by Student Subpopulation

	Ninth Graders		Tenth Graders		Exceptional Students		Regular and Gifted	
Model	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
National Board								
Certified	0.145***	0.102***	0.097***	0.042**	0.138*	0.182**	0.132***	0.078***
Pending	0.032***	0.031***	0.009	0.008	0.115***	0.023	0.012	0.014
Failed/Withdrawn	0.021	0	-0.048*	-0.047*	0.017	0.016	-0.003	-0.023
Teacher in subject area	0.13***	0.124***	0.104***	0.1***	0.296***	0.326***	0.07***	0.056***
Salary step 1 or 2	-0.004	-0.032**	-0.065***	-0.081***	-0.014	-0.037	-0.034***	-0.059***
State Certified HS math	0.054***	0.045***	0.058***	0.057***	0.116***	0.103***	0.045***	0.042***
State Certified MS math	0.028***	0.033***	0.009	0.032	0.035	0.035	0.011**	0.021***
Graduate degree	0.019***	0.027***	0.002	0.009	0.005	0.008	0.012***	0.021***
Undergrad selectivity	0.04***	-0.011	-0.008	-0.018	-0.028	-0.048	0.035***	-0.005
Constructed*selectivity	-0.01***	0.005	-0.026***	-0.011**	-0.026*	0.007	-0.02***	-0.01***
School fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Adj R2	0.68	0.68	0.68	0.69	0.48	.50	0.68	0.69
Sample size	68360	68360	39637	39637	10162	10162	97835	97835

Asterisks indicate level of statistical significance of the coefficient from which reported effect sizes are derived.
All models include student controls and year fixed effects, as shown in model 1.

Individual Student Effects

Although we have controlled for a substantial number of exogenous indicators of student performance in previous models of student outcomes, it is still possible that unobserved differences in student readiness to learn that correlate with assignment to an NBC teacher may bias our estimates of the effect of teacher attributes on student outcomes. In the last two reported models (table 6), we display results from student fixed effects models of student achievement in mathematics. In this formulation of the model, we construct the mean of each variable for each student and then take the difference between the observed values in a given year from the within-student mean. This construct allows us to measure the within-student effects of various factors on student outcomes (Greene, 2000). Note that the sample size is reduced to 72,387 in these specifications. Students who appear only once in the data set drop out of the analysis, as do control variables that do not change over time. Because the dependent variable now measures gain (or loss) in test score relative to the mean, the prior test score is also excluded from the model.

Results for students who have two test scores are reported in table 6. NBC remains positive and statistically significant (p=.015). The estimated effect size for the new dependent variable, based on a standard deviation of 78, is 0.06 to 0.07. Other conclusions are also generally unchanged by the new specification. Students with teachers who are applicants for NBC have no advantage over other students. However, students with teachers who failed or withdrew from NBC were less successful than others (not significant). Teaching experience and graduate education are more important in this formulation; having a state certification or a teacher–in-field are less important in these models.

Table 6. Student Fixed Effects Models

	Model 14	Effect Size Model 14	Model 15	Effect Size Model 15
Gifted program	11.365	0.145	10.286	0.131
	(0.007)***		(0.014)**	
Ever suspended	-3.409	-0.044	-3.644	-0.047
	(0.022)**		(0.014)**	
Days absent	-0.596	-0.008	-0.566	-0.007
	(0.000)***		(0.000)***	
Retained	-17.707	-0.226	-17.216	-0.220
	(0.000)***		(0.000)***	
GPA	6.635	0.085	6.629	0.085
	(0.000)***		(0.000)***	
Grade 10	6.646	0.085	7.351	0.094
	(0.012)**		(0.005)***	
Math effort	-4.281	-0.055	-4.363	-0.056
	(0.000)***		(0.000)***	
Math conduct	3.032	0.039	3.036	0.039
	(0.000)***		(0.000)***	
ELL in past 2 years	-17.112	-0.219	-16.650	-0.213
	(0.000)***		(0.000)***	
Below grade	-1.277	-0.016	-0.701	-0.009
	(0.377)		(0.628)	
Above grade	1.356	0.017	1.471	0.019
	(0.337)		(0.298)	
Teacher Attributes				
National Board Certified	5.441	0.070	4.900	0.063
	(0.015)**		(0.028)**	
Pending	-0.321	-0.004	-0.867	-0.011
	(0.856)		(0.625)	
Failed/Withdrawn	-6.423	-0.082	-5.565	-0.071
	(0.066)*		(0.112)	
Graduate degree	3.861	0.049	3.955	0.051
	(0.000)***		(0.000)***	
Teacher in subject area	2.280	0.029	2.537	0.032
	(0.150)		(0.109)	
Salary step 1 or 2	-4.346	-0.056	-5.146	-0.066
	(0.058)*		(0.025)**	
Undergrad selectivity	0.345	-0.009	0.561	-0.014
	(0.596)		(0.388)	
Constructed*selectivity	-0.143	0.004	-0.319	0.008
	(0.623)		(0.275)	

Table 6. Student Fixed Effects Models (cont.)

State Certified HS math	-0.929	-0.012	-0.858	-0.011
	(0.341)		(0.380)	
State Certified MS math	2.444	0.031	2.146	0.027
	(0.018)**		(0.038)**	
School Attributes				
Enrollment			-0.007	0.000
			(0.000)***	
Per pupil expenditures			-0.005	0.000
			(0.000)***	
Percent administrators				
Student mobility			-0.557	-0.007
			(0.091)*	
Pct absent 21+ days			-0.783	-0.010
			(0.000)***	
n acts crime or violence			-0.013	0.000
			(0.201)	
School year 2002	73.817	0.943	72.552	0.927
	(0.000)***		(0.000)***	
School year 2003	153.075	1.956	151.660	1.938
	(0.000)***		(0.000)***	
n of observations	72387		72387	
Adj R2	0.29		0.29	

P-values reported in parentheses.

VI. Summary and Conclusions

Using individual student data linked to teachers, this study examined the association between teacher quality indicators and student achievement in mathematics in the ninth and tenth grades. Under a variety of specifications and for a variety of subsamples we found robust evidence that observable teacher characteristics provide important signals about teacher quality. In particular, NBC proved to be both an effective signal of teacher quality and a valid discriminator of teacher quality among applicants. Indeed, seven of nine indicators of teacher quality that were included in the analyses resulted in appropriately signed and statistically significant evidence of their influence on student outcomes. Among those indicators, having an in-subject-area teacher, NBC, and regular state certification had the largest effect sizes.

These findings suggest that school systems that wish to target pay increases to teachers of the highest quality can use NBC for this purpose. Such a strategy will benefit students in the long run if NBC has the desired effect of attracting better candidates into teaching through incentives that are targeted to top performers, and by raising the professionalism and prestige associated with teaching. To increase student outcomes in the nearer term, the challenge for school systems will be to implement professional development programs or strategies that change practices so that more teachers adopt methods used by those who have already earned NBC.

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