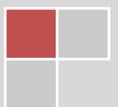


2013

Student Access to Qualified High School Mathematics Teachers: A Multilevel Analysis

In this study, I explore variation in 9th grade mathematics students' access to qualified teachers seven years after the implementation of NCLB. I draw on restricted-use data from the High School Longitudinal Study of 2009, which includes over 12,000 students linked to mathematics teachers in over 700 public schools. I conducted a multilevel logistic regression to explore which student- and school-level factors were associated with students' access to qualified teachers. Students taking lower level classes and those in schools serving socioeconomically disadvantaged populations have lower odds of having a qualified teacher. In addition, several facets of school's working conditions are associated with students' access to qualified teachers, including a measure of principal quality.



Introduction

Teacher quality is a critical school resource in terms of student achievement. In recent years, researchers have provided considerable evidence to support the intuitive notion that teachers represent the school input with the greatest potential to impact student achievement (e.g., Rivkin, Hanushek, & Kain, 2005; Rowan, Correnti, & Miller, 2002). Teachers' contribution to student achievement is thought to be especially strong for low-achieving students, yet decades of research shows that such students tend to have less well-qualified teachers. Teachers have been unevenly distributed both within schools, in that students in lower academic tracks have had less well-qualified teachers (Oakes, 1990; Kelly, 2004), and across schools, such that qualifications of teachers tend to be lower in disadvantaged, low-income, and high-minority schools (Clotfelter, Ladd, Vigdor, & Wheeler, 2007; Hanushek, Rivkin & Kain, 2004). Not surprisingly, these inequities in students' educational opportunities have been linked to disparities in educational outcomes. The achievement gap between more and less advantaged students can be attributed in part to the inequitable distribution of teachers across schools (Clotfelter, Ladd & Vigdor, 2010).

Numerous educational policy efforts, including the highly qualified teacher provisions under the No Child Left Behind Act (NCLB), attempt to improve students' access to qualified teachers as a mechanism to enhance student achievement and reduce the achievement gap through human capital reforms. Policies that attempt to increase student achievement by increasing students' access to such teachers implicitly assume that teachers with certain qualifications are more capable of improving student achievement than their less-well-qualified counterparts. However, research indicates that not all teacher qualifications are related to student

achievement (Goldhaber & Brewer, 1997); for example, teachers with generic master's degrees are no more effective than their colleagues without master's degrees.

On the other hand, research indicates that the relationship between qualifications and student achievement may vary as a function of the grade and subject taught. For example, while elementary school teachers tend to be generalists, high school teachers often teach one or two subjects. Thus, subject-matter knowledge may be a more salient qualification for high school teachers than for elementary school teachers. Among high school math teachers, researchers have found evidence that indicators of subject-matter knowledge are associated with teacher effectiveness (Goldhaber & Brewer, 1997; 2000).

The purpose of the current study is to provide information regarding whether students continue to experience inequitable access to qualified teachers 7 years after the passage of NCLB. I focus on teacher qualifications instead of effectiveness for two reasons: 1) data on teacher effectiveness are not available in national dataset, and 2) as a practical matter, many school districts do not have information on teacher effectiveness either; thus, findings on teacher qualifications might more directly inform policies and decisions. I examine high school math teachers because the ultimate goal of most educational policies is to bolster student achievement, and the relationship between teacher qualifications and student achievement tends to be strongest for secondary math (Rice, 2003; Wayne & Youngs, 2003). Thus, the distribution of teacher qualifications among high school math teachers is likely to be related to the distribution of teacher effectiveness and therefore has implications for student achievement and achievement gaps between more and less advantaged students.

Drawing from a nationally representative sample of students enrolled in 9th grade mathematics during the 2009-2010 school year, I investigate 9th grade mathematics students' access to teachers with qualifications that have been linked to greater student achievement. Extending on prior work regarding teacher distribution, I explore sorting of students to teachers within schools as well as between schools. I use data from school year 2009-2010 to address whether students continue to have inequitable access to qualified teachers, despite policies of the past decade that sought to improve low-income students' access to qualified teachers. Furthermore, I draw on previous research to explore the factors related to within- and between-school sorting in an effort to inform policies and practices at the federal, state, and local level intended to address inequities in the distribution of human capital resources.

Review of the Literature

In this section, I will review the work on the relationship between teacher qualifications and student performance on standardized assessments – focusing on research concerning teachers of mathematics - as well as research on factors related to the distribution of teachers. I identify those qualifications that previous research indicates are related to student achievement, and derive the outcome for my analyses based on these qualifications. I also identify working conditions with the potential to influence students' access to qualified teachers, to be used in the current study as independent variables theorized to be related to students' access to qualified teachers.

Teacher Qualifications and Student Achievement. Researchers have explored how a number of teacher characteristics relate to student achievement. To be considered a “highly qualified” teacher under NCLB, teachers must have obtained at least a bachelor's degree, state

certification in the grade and subject taught, and demonstrated subject matter knowledge. These criteria are intended to ensure a minimum competency level in order to protect students from incompetent teachers. However, the research on the relationship between these characteristics and student achievement is mixed.

Regarding certification, Aaronson, Barrow and Sander (2007) examined data on over 84,000 students attending public high schools in Chicago over a three-year period and found that certification status accounted for very little of the variance in teacher quality (as measured by value-added scores). In contrast, some evidence supports the notion that certification provides a “floor” of teacher quality and that teachers lacking certification are less effective. In contrast, Goldhaber and Brewer (2000) used data from the National Educational Longitudinal Study (NELS) of 1988 to examine relationships between certification status and student achievement in 12th grade. Teachers with any type of certification to teach math (emergency, alternative, or standard certification) outperformed teachers with no certification or who were certified in a subject other than math. Using administrative data on four cohorts of 10th graders in North Carolina, Clotfelter, Ladd, and Vigdor (2010) found that being certified in math increases the average achievement of a teacher’s students in a math course on average by about 0.11 standard deviations.

These conflicting findings suggest a need for further research, but decreasing variation in teacher qualifications limits researchers’ ability to address questions about the relationship between certain qualifications and student achievement. NCLB stipulates that teachers must obtain full state certification in order to be considered “highly qualified” and that Title I funds can only be used to hire teachers that meet the highly qualified provisions. In the HSLs:09 dataset, 98.8% of students are taught by teachers who are certified to teach math in grades 9

through 12. The decrease in variation will pose challenges for any researchers wishing to pursue the issue of whether certification impacts student achievement. Similarly, while NCLB specified that teachers must have a bachelor's degree to be highly qualified, as a practical matter almost no teachers lack this credential. In the HSL:09 dataset, over ninety-nine percent of students are taught by teachers with a bachelor's degree, which is consistent with research from a decade earlier, when virtually all teachers had a bachelor's degree (Lewis et al., 1999).

Several studies reveal that indicators of high school mathematics teachers' content knowledge are related to student achievement gains. Using data from the Longitudinal Study of American Youth, Monk and King (1994) demonstrated that each additional course a teacher has taken in math improves student mathematics achievement by about three quarters of one percent of a standard deviation. However, in a more recent study using administrative data from Florida, Harris and Sass (2011) found no evidence that the quantity of mathematics coursework is associated with greater contribution to student achievement.

Research also indicates that the type of degrees held by high school mathematics teachers is associated with greater student achievement. Both Rowan, Chiang, and Miller (1997) and Goldhaber and Brewer (1997, 2000) examined the NELS:88 data (a nationally representative sample). Rowan et al. found that having an undergraduate major in mathematics or a graduate degree in math was a positive predictor of 10th-grade student achievement. Goldhaber and Brewer showed that after controlling for other characteristics, having a master's degree in math is associated with student achievement gains in math in both 10th grade (Goldhaber & Brewer, 1997) and in 12th grade (Goldhaber & Brewer, 2000). Summaries of the literature on teacher characteristics and student achievement by Wayne and Youngs (2003) and Rice (2003) suggest

that high school students learn more mathematics when their mathematics teachers have additional subject-specific degrees or coursework in mathematics and that students learn more when their teachers have standard mathematics certification (Wayne & Youngs, 2003).

While evidence regarding other teacher characteristics is conflicting, numerous studies have demonstrated that veteran teachers are, on average, more effective than their novice counterparts, with returns to experience appearing most dramatically early in the teaching career (Clotfelter, Ladd, and Vigdor, 2006; Rivkin, Hanushek, and Kain, 2005; Rockoff, 2004). However, recent studies that seek to isolate the effect of experience on teacher effectiveness yields mixed results with regard to high school mathematics teachers. Using a North Carolina statewide administrative dataset with four cohorts of 10th graders (1999 through 2002), Clotfelter, Ladd and Vigdor (2010) demonstrated that experienced teachers outperform novice teachers. The authors concluded that teachers with some experience are more effective than novice teachers, but, beyond the first five years, additional experience adds little to teachers' effectiveness. Also using data on public schools in North Carolina, for school years 2005-2006 through 2009-2010, Henry, Fortner, and Bastian (2012) found that novice teachers of three different mathematics courses experience gains of 0.06 to 0.09 standard deviation units between their first and second year of teaching. Based on a statewide administrative dataset from Florida Harris and Sass (2011) found that more experienced teachers appear more effective in teaching elementary and middle school math; however, they did not find similar results for high school mathematics – in fact, they found that more experienced high school teachers are generally less productive than when they were novices.

Inequities in the Distribution of Teachers: Within-School Sorting. The manner in which teachers and students are sorted to one another within schools may exacerbate inequality. For example, Oakes (1990) found that teachers of low-track classes in junior and senior high school are considerably less well-qualified than are teachers of other classes. Drawing on data from the nationally representative 1990-1991 Schools and Staffing Survey (SASS), Kelly (2004) found evidence that more experienced teachers are more likely to teach higher level courses at the high school level. Examining statewide data on public school teachers in Florida during the period 1997–2003 and the 1999–2000 SASS and its Teacher Follow-up Survey (TFS) data set, Feng (2010) found that on average, Florida teachers with fewer than two years of experience had a larger proportion of low-performing students, students with disciplinary problems, minorities, low-income students, students in special education, and limited English proficient students. Using Miami-Dade County data spanning 2003-2004 through 2008-2009 school years, and comparing teachers who teach in the same grade and school in a given year, Kalogrides, Loeb, and Béteille (2011) demonstrated that less experienced teachers are assigned students with lower average prior achievement, more prior behavioral problems, and lower prior attendance rates than their more experienced colleagues.

The literature suggests some reasons for this sorting. Specifically, research suggests that teachers often prefer higher-level classes. Raudenbush, Rowan, and Cheong (1992) showed that within a teacher's daily schedule, the difference between an academic and non-academic course lead to a 0.93 standard deviation in teacher satisfaction. As teachers gain experience and priority status, their desire for more satisfying class assignments may result in the patterns observed by Feng (2010) and Kalogrides, Loeb, and Béteille (2011). Kelly (2004) refers to this within-school

sorting of teachers as contributing to “the magnification of inequalities in opportunity to learn produced by tracking” (p. 55).

Inequities in the Distribution of Teachers: Between-School Sorting. Just as research suggests certain patterns of teacher distribution within schools, there is evidence of patterns in the between-school distribution of teachers as well. While many have documented the disparities in teacher qualifications between schools based on the demographics of students served, these student characteristics may be proxies for other factors that shape teachers’ preferences. In the following section, I will describe the research on teacher sorting along the dimension of school context, defined by Raudenbush and Willms (1995) as “school-level factors that are exogenous to practices of the school’s administrators and teachers” (p. 310), such as the socioeconomic and racial composition of the student body. I then turn to research on what I refer to as school working conditions, sometimes known as school climate, which includes administrative policies and attitudes, values and expectations of students, teachers, and administrators (Ma, Ma & Bradley, 2008).

Between-School Sorting: School Context. Student demographics have consistently been linked to teacher characteristics, such that schools with greater proportions of low-income and minority students tend to have less well-qualified teachers than schools serving more advantaged student populations. For example, Hanushek, Rivkin, and Kain (2004) analyzed data on more than 300,000 Texas teachers during 1993-1996 and found that school characteristics played a large role in influencing teacher movements across schools and teacher exits from the system. Schools serving low-achieving students (as measured by district test scores) and larger proportions of minority students had greater difficulty retaining teachers than high-achieving,

low-minority schools. The authors contend such distribution patterns reflect teacher preferences for higher-achieving students and non-minority students, though they acknowledge that student characteristics may be proxies for other factors that shape teachers' preferences.

Using data from North Carolina public school students in 5th grade during 2000-2001, Clotfelter, Ladd, and Vigdor (2006) found evidence of between-school sorting such that teachers with better qualifications (more experience, degrees from more highly ranked colleges, or higher licensure test scores) typically work in schools serving higher proportions of advantaged students (e.g. whiter, wealthier, with more highly educated parents and higher prior test scores).

Clotfelter, Ladd, Vigdor, and Wheeler (2007) noted similar patterns when comparing high and low poverty schools between 1995 through 2004; furthermore, they found that the differences between the percentages of inexperienced teachers in high and low poverty schools have increased over the ten-year period, to the disadvantage of students in high poverty schools.

Guarino, Brown, and Wyse (2011) explored data on all teachers in North Carolina from 1995 to 2006 and found that school demographic characteristics play a dominant role in intra-system sorting. Specifically, they found that wealthier and majority white schools attract a disproportionate share of first-year teachers with desirable characteristics such as degrees from highly competitive universities and high Praxis scores. In addition, teachers in "at-risk" schools (schools with both majority non-white and a high fraction of students in poverty) are more than two percent more likely to leave their school for another school in the district every year of their career. Schools whose performance earned a classification as "low growth" under the state accountability policy struggle to retain teachers with desirable observable characteristics. Specifically, teachers with high Praxis scores, National Board certification, or a degree from a

highly competitive undergraduate institution all show slightly higher probabilities of leaving the school system if they are in low-growth schools.

Using both statewide administrative data from Florida and the 1999-2000 SASS, Feng (2010) found that “in Florida and elsewhere, teachers with 6–29 years of experience were more likely to teach in schools with a lower percentage of LEP students, fewer poor students, and a smaller proportion of minority students” (p. 294). Furthermore, in Florida, teachers with less than two years of experience taught in schools with lower average student achievement and more disciplinary incidents per student compared with teachers with more than six years of experience.

Lankford, Loeb, and Wyckoff (2002) found similar results using data on teachers working in the New York State system in 1999-2000. They examined teachers’ experience, highest degree, certification, whether they passed the teacher exam on their first attempt, and college selectivity. Higher proportions of low-income, low-achieving, and non-white students have teachers with no teaching experience, who are not certified, who failed the teacher exam on the first attempt, or who have a B.A. from a non-selective college, relative to non-poor, higher-achieving, and white students. Using administrative data from Georgia in academic years 1994–1995 through 2000–2001, Scafidi, Sjoquist, and Stinebrickner (2007) found support for the notion that teachers are much more likely to leave high poverty schools, but also present evidence that teachers are more likely to leave a particular type of poor school—one that has a large proportion of minority students.

Turning to math teachers more specifically, and using nationally representative data from the SASS and TFS (focusing on 1999-2000 data), Ingersoll and Perda (2010) found that “high-poverty, high-minority, urban and rural public schools have among the highest rates of both

attrition and migration of math and science teachers. Moreover, in the case of those moving between schools, a large annual asymmetric reshuffling of a significant portion of the math science teaching force creates a net loss on the part of poor, minority rural and urban schools and a net gain to nonpoor, nonminority suburban schools” (p. 588).

Between-School Sorting: The Role of Working Conditions. Though the research on school context suggests teachers prefer working with higher-income and white students, Hanushek, Rivkin and Kain (2004) acknowledged that student characteristics may be proxies for other factors that shape teachers’ preferences. That is, if lower income and minority students attend schools with less attractive working conditions, the patterns of teacher behavior that suggest a preference for wealthier and whiter students might be at least partially explained by preferences for better working conditions. Ingersoll’s (2001) work suggests school staffing problems result from a “revolving door”, where large numbers of qualified teachers depart their jobs out of dissatisfaction with aspects of the school environment, such as student discipline problems. As noted earlier, working conditions include administrative policies and attitudes, values and expectations of students, teachers, and administrators (Ma, Ma & Bradley, 2008). In this section I describe the research on the relationship between school working conditions and teacher career decisions.

School leadership. A number of studies have documented the importance of teachers’ perceptions of school leadership for teacher retention. Hornig (2009) used a survey of 531 teachers in a California elementary school district to disentangle student characteristics and working conditions to determine if the characteristics of students themselves directly affected teachers’ decisions to migrate or served as proxies for working conditions in the schools, and

found that teachers identify administrative support as significantly more important than student characteristics when they were selecting a school in which to work. Using administrative data from North Carolina combined with a 2006 statewide survey administered to all teachers in the state, Ladd (2011) explored the relationship between teachers' working conditions and teachers' intended movement away from their schools. Independent of other school characteristics such as the racial mix of students, teachers' working conditions, especially school leadership, are highly predictive of teachers' intended movement away from their schools (Ladd, 2011). Boyd et al. (2011) explored the relationship between school factors and teacher retention decisions in New York City; the authors separate the effects of teacher characteristics from school characteristics by modeling the relationship between the assessments of school working conditions by one set of teachers and the turnover decisions by other teachers in the same school. Similar to Ladd (2011), they found that teachers' perceptions of the school administration have the greatest influence on teacher retention decisions. Boyd et al. (2011) showed that teachers' perceptions of the school administration had much greater influence on teacher retention decisions than other factors examined, which included staff relations, students, facilities, and safety.

Two studies based on the nationally representative Schools and Staff Survey (SASS) and the Teacher Follow-up Survey (TFS) confirm the findings from these local studies. Using 1990-1991 SASS and 1991-1992 TFS data, Ingersoll (2001) found lower turnover rates in schools that provide more administrative support to teachers. In an exploration of the 2003-2004 SASS and 2004-2005 TFS, Grissom (2011) found that principal effectiveness is associated with greater teacher satisfaction and a lower probability that the teacher leaves the school within a year; furthermore, this positive impact of principal effectiveness on teacher retention is even greater in disadvantaged schools.

Collegial relations. Both quantitative and qualitative studies find that teachers view collegial relations as a factor in teacher retention. Based on a survey of a stratified random sample of 400 teachers in Washington State, Elfers, Plecki, and Knapp (2006) reported that the majority of teachers consider the presence of staff with whom they feel comfortable working, collegial community with other teachers, presence of staff who share their values about teaching and schooling, and staff willingness to “go the extra mile” to be strong reasons to stay in their school. Johnson, Kraft, and Papay (2012) found similar results based on a 2008 survey of teachers in Massachusetts; the extent to which teachers have productive working relationships with their colleagues was a statistically significant predictor of both teacher satisfaction and stated intention to remain in the school.

Facilities and resources. School facilities and resources may also play a role in attracting and retaining teachers. Teachers in an elementary school district in California identified school facilities as being significantly more important to teachers than student characteristics when they were selecting a school in which to work (Hornig, 2009). Johnson, Kraft and Papay (2012) used a 2008 working conditions survey given to all Massachusetts teachers to examine how working conditions are related to teachers’ career intentions, and find that facilities and resources were especially relevant factors regarding whether teachers planned to transfer schools. In contrast, Ladd (2011) found teachers’ perceptions of facilities to be a significant predictor of teachers’ departures among elementary school teachers, such that teacher departures were actually higher in schools in which teachers had positive perceptions of the facilities; however, this was not a significant predictor of departure among middle and high school teachers.

Teacher autonomy and decision-making. Teachers' autonomy and roles in school governance have also been linked to retention. Analyses of multiple waves of the SASS and TFS data indicate that schools with higher levels of faculty decision-making influence and autonomy have lower levels of turnover (Ingersoll, 2001; Ingersoll & May, 2012). In Johnson, Kraft and Papay's (2012) study of teachers in Massachusetts, teachers in schools where school average perceptions of teacher involvement in decision-making were higher were less likely to plan to transfer or leave the profession. Teacher autonomy may be especially important in terms of mathematics teachers' career decisions. Ingersoll and May (2012) found that a one-unit increase in average teacher autonomy between schools was associated with a 70% decrease in the odds of a mathematics teacher departing and was by far the single largest relationship they found (p. 453).

Time. In Johnson, Kraft and Papay's (2012) analysis of survey data from Massachusetts teachers, the authors found that teachers' perceptions of whether teachers have sufficient instructional and non-instructional time were significantly related to teachers' intentions to remain in their schools. Similarly, Ladd (2011) found that middle schools teachers' perceptions of having sufficient time for planning and collaboration were associated with lower likelihood of moving or leaving the profession. Among elementary school teachers, those who reported spending more time on school-related activities outside the regular school work day were more likely to plan to move to another school or district. However, time was not a significant predictor of teachers' actual departures (Ladd, 2011).

Student behavior. Schoolwide disciplinary climate also influences teachers' decisions about where to work. Ingersoll and May's (2012) analysis of the 2003-04 SASS data indicates

that turnover is lower in schools where teachers perceive fewer discipline problems, consistent with Ingersoll's (2001) earlier work using the 1990-1991 SASS data. Similarly, Boyd et al. (2011) find that retention of teachers in New York City is higher in schools with more positive ratings of student behavior. All three studies control for school context.

The Study

The existing literature has explored teacher satisfaction, retention, or turnover as outcomes. As Ingersoll and May (2012) note, some turnover is “normal, inevitable, and can be efficacious” (p. 436) for individuals and organizations, but the considerable amount of turnover in the teaching profession is costly and time-consuming, and therefore is an important consideration for policymakers. In addition, the body of work reviewed here suggests that the costs of teacher turnover are borne disproportionately by disadvantaged students, with benefits accruing to their more advantaged peers. If the goal is to improve educational productivity, teacher satisfaction and turnover are intermediary outcomes; the ultimate outcome is students' access to effective teachers. In this study I directly investigate this outcome, using specific qualifications as a proxy for effectiveness. Building on the prior literature, I also seek to identify the school working conditions that are associated with student access to qualified teachers.

I update past work using 2009 data to explore variation in 9th grade mathematics students' access to qualified teachers seven years after the implementation of NCLB. I devise a definition of a “qualified” teacher based on previous research on the qualifications that are related to high school mathematics teachers' productivity, as measured by student achievement (Goldhaber & Brewer, 2000; Wayne & Youngs, 2003). While some prior studies have used multilevel approaches to account for teachers being nested within schools (e.g. Ingersoll & May,

2012), fewer studies have used multilevel modeling to take into account the sorting of students to teachers within schools as well as across schools. The current study is unique in that it extends on prior work by using nationally representative data to explore factors related to students' access to qualified teachers both within and between schools.

While it is possible that school context moderates the relationship between working conditions and students' access to qualified teachers, few researchers have explored whether the relationships between working conditions and their outcomes are contingent upon contextual factors. Those that do so have found significant interactions. For example, Grissom (2011) found that the positive impact of principal effectiveness on teacher retention is even greater in disadvantaged schools. His finding suggests the importance of considering contingent relations in studies that investigate the impact of school working conditions. Similarly, Ladd (2011) finds that teachers' intended departures are more responsive to the quality of school leadership in schools with higher proportions of Black students compared to schools with lower proportions of Black students. By including measures of both school context and working conditions, the conceptual framework of the current study extends on the frameworks used in previous studies and offers insight as to the extent to which school context moderates the relationship between working conditions and students' access to qualified teachers.

The specific research questions are below:

1. Do the odds of having a “qualified”¹ mathematics teacher differ depending on students' academic and demographic characteristics?

¹ For the purpose of this study, I derive a notion of a “qualified” teacher based on prior research. This body of work suggests that the following teacher characteristics are associated with greater student achievement gains in high school mathematics: certification in mathematics and a BA , highest degree, or 7 or more courses in mathematics.

2. Are students in schools with less favorable characteristics (e.g. schools serving predominantly lower-achieving students of lower socioeconomic status) less likely to have qualified teachers relative to students in schools serving more advantaged populations?
3. Do school working conditions influence students' access to qualified teachers across schools? Do school characteristics explain variation across schools in the relationship between student background and the odds of having a qualified teacher?

This study contributes to the literature base in multiple ways: 1) uses a nationally representative dataset compiled since the passage of the No Child Left Behind Act, whereas prior studies have focused on specific states and/or districts or data from the 1990s; 2) investigates within-school sorting as well as between-school sorting of teachers; and 3) builds on prior studies of teacher preferences to examine whether demographics of the school population are related to sorting of high school mathematics teachers to students, and whether teachers' working conditions moderate that sorting.

As opposed to previous work, which focuses on teacher satisfaction and/or turnover as an outcome, this study investigates students' access to teacher with qualifications known to be related to student achievement. Since the analytic sample consists of students enrolled in high school mathematics courses, these qualifications include certification in mathematics and degrees or significant coursework in mathematics. Of particular interest is whether positive working conditions might mitigate the expected positive matching of teachers to students – in other words, whether positive working conditions can increase the likelihood that less advantaged students are exposed to more highly qualified teachers.

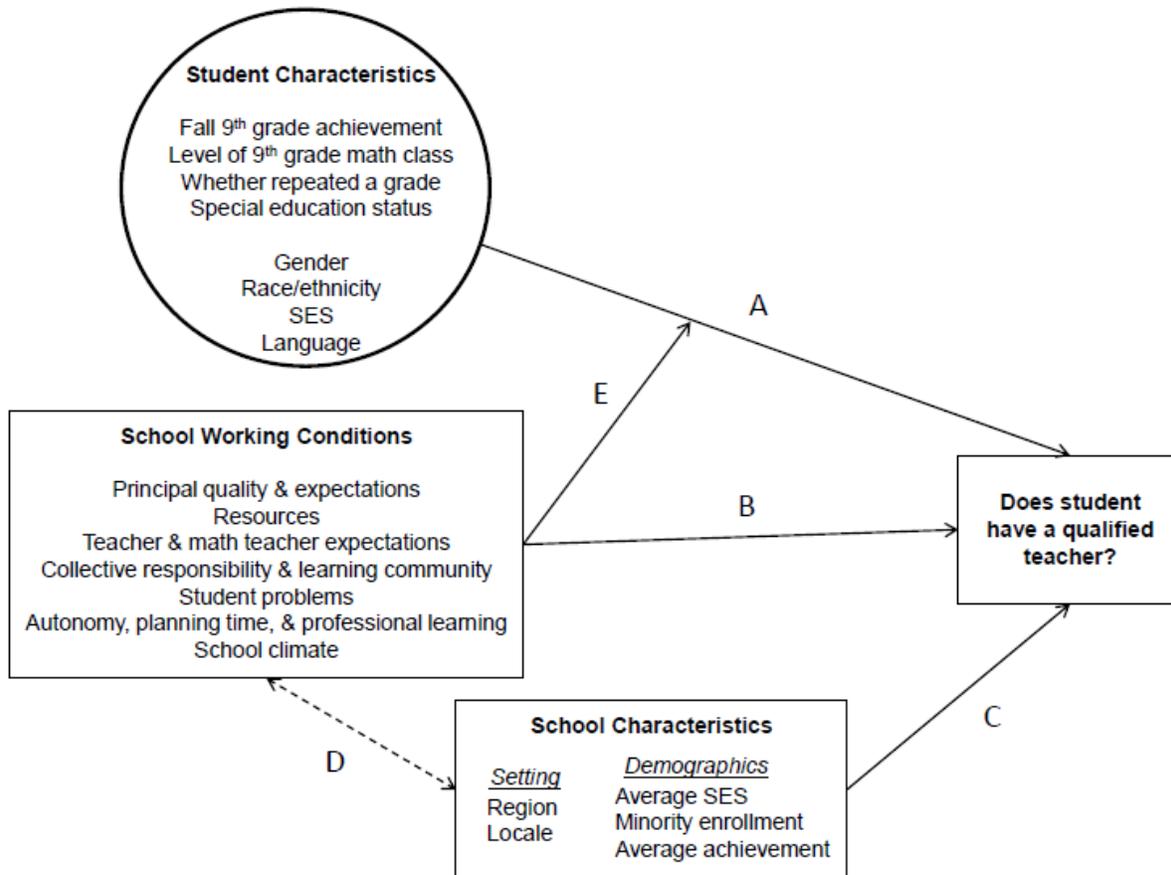


Figure 1. Multilevel heuristic model relating students' academic background and teachers' working conditions to the probability of a student having a qualified teacher.

Conceptual Model. The conceptual model in Figure 1 delineates hypothesized relationships between variables. Within schools, I expect higher-achieving students and those in higher level math classes to have a higher probability of having a qualified teacher; conversely, I expect students in lower level math classes to have a lower probability of having a qualified teacher. The main effect of students' academic background on the likelihood of having a more qualified teacher is depicted by arrow A in Figure 1. The analytic results captured by arrow A address research question 1. I expect students in schools with more favorable characteristics – e.g. schools serving wealthier students with higher average levels of achievement – to have greater access to qualified teachers.² The relationship between school

² I expect qualified teachers to be attracted to schools with higher achievement. One might speculate that the teacher's qualifications are causally related to student achievement. However, the achievement measure is taken

characteristics and student access to a qualified teacher is indicated by arrow C. The analytic results that are captured by arrow C address research question 2.

Between schools, the direct effect of working conditions on the likelihood of having a qualified teacher is indicated by arrow B. Since the literature suggests teachers stay longer in schools with positive work environments (Johnson, Kraft & Papay, 2011) and more effective principals (Grissom, 2011), I expect students to have greater access to qualified teachers in schools with more favorable working conditions. The analytic results captured by arrow B address research question 3. I allow for the possibility that school-level factors might interact, such that working conditions might have a stronger influence on some schools than others; these potential interactions are denoted by arrow D. Finally, I explore whether aspects of teachers' working conditions moderate the within-school relationship between students' academic background and access to qualified teachers. Arrow E indicates this hypothesized cross-level interaction.

Data Source

Data for this dissertation come from the High School Longitudinal Study of 2009 (HSLs:09). Sponsored by the U.S. Department of Education's National Center for Education Statistics (NCES), the HSLs:09 base year data includes a randomly selected sample of over 21,000 9th-graders in more than 900 public and private high schools. Students took assessments and a survey online, and students' parents, principals, and mathematics and science teachers completed surveys on the phone or on the Web (Ingels, et al., 2011).

Sample selection for the HSLs:09 was based on two-stage process. First, stratified random sampling and school recruitment resulted in the identification of 1,889 eligible schools, of which 944

from the fall of 9th grade, before teachers have an opportunity to influence achievement. As a sensitivity check, analyses could be rerun without the schools that include grades lower than ninth grade (since in schools with lower grades, the qualifications of ninth grade teachers may have influenced student achievement through contextual effects, or if the teacher in question taught some lower-grade classes).

participated. In the second stage of sampling, students were randomly sampled from each the participating schools, yielding 25,206 eligible selections (about 27 students per school). The overall student assessment completion rate in the based year was 83 percent (weighted) and the school administrator completion rate was 94.5 percent. The weighted mathematics teacher response rate was 71.9 percent (Ingels, et al., 2011).

Weights. The HSLs:09 dataset provides several types of sampling weights to account for the complex survey design and produce estimates for the target population. The use of weights is required to produce estimates for the target population. In the descriptive analyses, the mathematics course enrollee weight (W1MATHTCH) is used to produce subpopulation estimates for ninth-grade students enrolled in a mathematics course, and the school weight (W1SCHOOL) is used to produce population estimates for U.S. schools providing instruction to 9th- and 11th-grade students (Ingels et al., 2011). To account for complex sampling in a multilevel framework, I applied the base year math-course enrollee analytic weight (W1MATHTCH) to level 1 and the school weight (W1SCHOOL) to level 2.

Analytic Sample. Although the full HSLs:09 sample includes data for 25,206 9th graders, the analytic sample used to explore the research questions includes fewer cases. The analytic sample includes only public school students who could be linked to a mathematics teacher in the 9th grade. The within-school analyses were also limited to schools in which at least two mathematics teachers responded to the survey.³ Based on these criteria, the analytic samples include approximately 12,900 9th grade students enrolled in approximately 730 schools.⁴

³ HSLs:09 does not include a teacher ID. To ascertain whether more than one mathematics teacher had responded to the survey, I aggregate the standard deviation of teacher experience to the school level. Schools with a standard deviation of 0 or with missing data will be eliminated from the multilevel analyses.

⁴ I use multiple imputation to avoid additional loss of cases due to missing data.

Measures

The HSLS:09 provides a range of information about students, students' mathematics teachers, and students' schools. The measures used in the current study are described below.

Qualified teacher: a dichotomous variable where 1 = teacher is certified to teach high school math, has a BA, highest degree, or at least seven different courses in math and/or statistics, and is in 5th or higher year of teaching; 0 = other teachers.⁵

Student Characteristics

- **Female:** dichotomous variable where 1 = female and 0 = male.
- **Race:** a series of dichotomous indicators regarding whether the student is Black, Hispanic, Asian, or Other.
- **High math:** dichotomous indicator of the level of math class, categorized based on the mathematics achievement scores of individual taking the courses, where 1 = advanced math, integrated math II, trigonometry algebra II and geometry; 0 = other courses.
- **Low math:** dichotomous indicator of the level of math class, where 1 = remedial math, pre-algebra, "other" math and 0 = other courses.
- **Math IRT:** students' math IRT score.
- **Special education:** dichotomous indicator where 1 = student in special education; 0 = student not in special education.
- **Repeat:** dichotomous indicator where 1 = student repeated at least one grade and 0 = student never repeated a grade.

School Characteristics

- **Region:** a series of dichotomous indicators of whether the school is in the West, Midwest, or Northeast (South is the reference group).
- **Locale:** a series of dichotomous indicators of whether the school is located in a town, rural area, or city (suburb is the reference group).
- **HiMin:** a dichotomous variable where 1 = proportion of non-White students exceeded 45% and 0 = proportion of non-White students less than 45%
- **SES:** student socioeconomic status derived with locale, aggregated to the school level.
- **Zmath:** student scores on the mathematics assessment given in the fall of 9th grade, aggregated to the school level.

Working Conditions

- **Principal quality:** on a 4-point continuum, the school mean of students' math teachers' reports for 5 items regarding whether the principal: deals with outside pressures

⁵ Given the conflicting findings regarding the relationship between experience and teacher effectiveness among high school math teachers (Harris & Sass, 2011; Clotfelter, Ladd, & Vigdor, 2010; Henry, Fortner & Bastian, 2012), I constructed two outcome measures: the one described and another that does not incorporate experience at all. Results were substantively similar. Findings presented use the outcome described in main text.

interfering with teaching, sets priorities and sees that they are carried out, communicates kind of school that is wanted to staff, lets staff members know what is expected of them, is interested in innovation and new ideas, and consults staff before making decisions affecting them. $\alpha=0.899$.

- **Resources:** on a 4-point continuum from “not at all” to “a lot”, the school mean of students’ math teachers’ reports for 7 items. The first 6 items ask whether teaching is limited by shortage of: computer hardware/software, support for using computers, textbooks for student use, instructional equipment for students, equipment for demonstrations, or by inadequate physical facilities. The 7th item asks whether lack of teacher resources and materials is a problem at this school (4-point continuum from “not a problem” to “serious problem”). $\alpha=0.830$.
- **Math teacher expectations:** on a 4-point continuum, the school mean of students’ math teachers’ reports for 8 items regarding whether math teachers in this school: set high standards for teaching, set high standards for students' learning, believe all students can do well, make goals clear to students, have given up on some students, care only about smart students, expect very little from students, and work hard to make sure all students learn. $\alpha=0.849$.
- **Collective responsibility:** on a 4-point continuum, the school mean of students’ math teachers’ responses to 7 items as to whether teachers at this school: help maintain discipline in the entire school, take responsibility for improving the school, set high standards for themselves, feel responsible for developing student self-control, feel responsible for helping each other do their best, feel responsible that all students learn, feel responsible when students in this school fail. $\alpha=0.876$.
- **Student problems:** 4-point continuum from “not a problem” to “serious problem”, the school mean of students’ math teachers’ responses to 8 items regarding: student tardiness, absenteeism, class cutting, dropping out, apathy, lack of parental involvement, unprepared to learn, poor health. $\alpha=0.874$.
- **Professional learning community:** on a 4-point continuum, school mean of students’ math teachers’ perceptions of 11 items regarding whether math teachers in this department: share ideas on teaching, discuss what was learned at workshop/conference, share and discuss student work, discuss lessons that were not successful, discuss beliefs about teaching/learning, share research on effective teaching methods, share research on ELL instructional practices, explore approaches for underperforming students, coordinate course content with other teachers, provide support to new math teachers, and are supported/encouraged by math department's chair. $\alpha=0.904$.
- **Autonomy:** math teachers’ perceptions of whether teaching is limited by lack of autonomy in instructional decision-making, reverse coded and dichotomized (0=teaching is limited by lack of autonomy; 1=teaching is not at all limited by lack of autonomy). Aggregated to the school level then dichotomized (1=more two-thirds of students’ math teachers report that teaching is not limited by lack of professional learning opportunities).
- **Planning time:** math teachers’ perceptions of whether teaching is limited by lack of planning time, reverse coded and dichotomized (0=teaching is limited by lack of planning time; 1=teaching is not at all limited by lack of planning time). Aggregated to the school level then dichotomized

(1=more two-thirds of students' math teachers report that teaching is not limited by lack of professional learning opportunities).

- **Professional learning opportunities:** math teachers' perceptions of whether teaching is limited by lack of professional learning opportunities, reverse coded and dichotomized (0=teaching is limited by lack of professional learning opportunities; 1=teaching is not at all limited by lack of professional learning opportunities). Aggregated to the school level then dichotomized (1=more two-thirds of students' math teachers report that teaching is not limited by lack of professional learning opportunities).
- **School climate:** on a 5-point continuum, principal ratings regarding the frequency of 14 types of events at this school: physical conflicts among students, robbery or theft, vandalism, student illegal drug use, student use of alcohol while at school, drug sales on way to/from school or on school grounds, student possession of weapons, physical abuse of teachers, student racial tensions, student bullying, student verbal abuse of teachers, in-class misbehavior, student acts of disrespect for teachers, student gang activities. $\alpha=0.837$.
- **Principal effort and expectations:** on a 4-point continuum, counselors' ratings on 6 items related to principal expectations. These items are whether the principal in this school: sets high standards for students' learning, believes all students can do well, works hard to make sure all students learn, has given up on some students, cares only about smart students, and expects very little from students. $\alpha=0.987$.
- **Teacher effort and expectations:** on a 4-point continuum, counselors' ratings on 7 items related to teaching staff expectations. These items are whether teachers in this school: set high standards for teaching, set high standards for students' learning, believe all students can do well, work hard to make sure all students learn, have given up on some students, care only about smart students, and expect very little from students. $\alpha=0.974$.

Higher values represent more positive assessments of working conditions. Unless otherwise noted, responses were provided along a 4-point continuum of “strongly agree” to “strongly disagree”; some questionnaire items were reverse coded to equate larger scale values with positive attributes. I used factor analysis (with varimax rotation) to create measures of principal support, resources, math teacher expectations, collective responsibility, student problems, and professional learning community. All factor scores were created at student level and aggregated to school level.

Analytic Approach

Population estimates of the means of continuous variables and percentages for categorical variables will be calculated in SPSS for each of the dependent and independent variables included in the analyses. To assess the extent to which high school math teachers are sorted across students, I will use a

factorial ANOVA to test for differences in student characteristics by whether the teacher meets the definition of qualified used in this study. When conducting descriptive analyses of HSLS:09 data, I use weights and the complex samples module to account for the complex sample design and different rates of non-response.

This research is conducted in a multilevel framework, which recognizes the nested structure of students within schools (Raudenbush & Bryk, 2002). Single-unit approaches (i.e. using the school or student as the unit of analysis) require untenable assumptions. School-level analyses ignore variability in the both the outcome and in independent variables across students within schools, while student-level analyses may result in overestimation of standard errors, leading to underestimation of school effects. In addition, the researcher must assume that the outcomes of all students in the school are identically influenced by the school-level independent variable (known as heterogeneity of regression slopes) (Lee, 2000). Multilevel models allow simultaneous modeling of relationships within and across multiple units of analysis. Thus, to further explore students' access to qualified teachers, I will use a multilevel model in which the math course taken by the student (high level vs. low level) predicts whether the student experiences a qualified teacher. At level 1, I will model whether a student has a qualified teacher i in school j as a function of the type of math course taken by the student (X_{qij}) and random error (r_{ij}).

$$\eta_{ij} = \beta_{0j} + \beta_{qj}X_{qij} + r_{ij}$$

Where

η_{ij} is a dummy variable indicating whether a student's teacher i in school j is qualified;

β_{0j} is the average proportion of students in school j whose teacher are qualified;

X_{qij} is the vector of $q = 1, \dots, q$ indicators of whether the math course is high or low level;

β_{qj} are the level-1 coefficients indicating the direction and strength of association between the math course type and teacher qualification; and

r_{ij} is the random error or unique effect of student ij on teacher qualification (the deviation of the student's log-odds of having a qualified teacher from their predicted log-odds)

Because it is difficult to interpret the coefficient in a logit regression, the results section will report the odds ratio, calculated as $\exp(\beta_{j2})$, where β_{j2} is the estimated coefficient from equation 1. In general, an odds ratio greater than one suggests that a one-unit increase in the predictor is associated with an increased probability of having a qualified teacher compared with the default of having a less well qualified teacher. On the other hand, an odds ratio of less than one implies that a one-unit increase in the predictor is associated with a decreased probability of having a qualified teacher.

To address research question two, at level 2, I will model β_{0j} (the schools' log-odds of students having a qualified teacher) as a function of a vector of school demographics - aggregated characteristics of students in the school (W_{sj}) and random school error (u_{0j}):

$$\beta_{0j} = \gamma_{00} + \gamma_{0s}W_{sj} + u_{0j}$$

Where

β_{0j} is the average the log-odds of students having a qualified teacher in school j ;

γ_{00} is the average log-odds of students having a qualified teacher across all schools;

W_{sj} is the vector of $s = 1 \dots, s$ school demographics (e.g. average prior achievement and SES);

γ_{0s} are the level-2 coefficients indicating the direction and strength of association between the school demographics and average log-odds of having a qualified teacher; and

u_{ij} is the school-level random error or unique effect of school j (the deviation of the school's level-2 coefficient from its predicted log-odds)

To answer the first part of the third research question, I will expand on the model for β_{0j} (the school average log-odds of its students having a qualified teacher) by adding a series of working

conditions and assessing whether the coefficients on school demographics that predict teacher qualifications are decreased by any of these additions. The twelve working conditions described in the measures section are explored.⁶ Dichotomous level-2 variables are uncentered and continuous variables are grand-centered. As a further test for contingent relations, in addition to the working conditions, I will also included a series of interaction terms between school demographics and working conditions. To investigate whether the effect of working conditions is different in different types of schools (i.e., a contingent relationship), I will compute a series of product terms between the working conditions and school demographic measures (average socioeconomic status and average prior achievement).

To answer the second part of the third research question, I will add level-2 predictors to the model for β_{1j} (the relationship between student achievement and log-odds of having a qualified teacher). I will explore teachers' working conditions that might decrease within-school sorting to assess whether the relationship between student achievement and odds of having a qualified teacher is moderated by particular school working conditions.

$$\beta_{1j} = \gamma_{10} + \gamma_{1s}W_{sj} + u_{1j}$$

I created 8 multiply imputed datasets to in order retain all cases in the analytic sample. For most school variables, less than 10% were missing data (exceptions were the school-level NCES scales of administrator and counselor perceptions, about 20% and 15% missing, respectively). I employ a multilevel logistic regression model in which the outcome is whether the student's 9th grade mathematics teacher met the definition of "qualified." To provide the most accurate standard errors for level 2 coefficients, I included the stratification variables, region and locale, in the between-schools model as suggested by L. Stapleton (personal communication, December 19, 2012). I report the population average results, which are based on fewer

⁶ Because each of these constructs is aggregated from the student to the school level, I also plan to explore whether the standard deviation (as a proxy for consistency of teacher perceptions) contributes to the model.

assumptions and are robust to erroneous assumptions about the random effects in the model (Heagarty & Zeger, 2000), and are more useful than the unit-specific results when desired inferences focus on group-level variables (O'Connell, Goldstein, Rogers & Peng, 2008). The term “likelihood” is used in a nontechnical sense; a greater likelihood of having a qualified teacher could refer to a greater probability, greater odds, or greater log odds (Lee & Burkam, 2003).

Results

While the vast majority of public school students have teachers who are certified to teach high school math, only about 54% of students have math teachers with a degree or significant coursework in math. Overall, about half of public school 9th grade math students have a math teacher meeting this construction of “qualified.” As seen in Table 1, students with qualified teachers are more often White, have higher average SES and math achievement, and are less likely to have repeated a grade or be in a low math course or special education relative to students with teachers that do not meet this definition of qualified.

Table 1. Student Characteristics by Teachers' Qualification Status

	All	Qualified	Not Qualified
<i>Variables:</i>			
% Female	49.6	49.3	49.6
% White	51.7	58.4	48.4
% Asian	3.4	3.2	3.4
% Black	13.3	11.0	14.2
% Hispanic	22.5	18.9	24.5
% Other	9.2	8.6	9.5
Mean SES	0.00	0.16	-0.08
(SE)	0.02	0.03	0.03
Mean math achievement	38.7	40.4	37.8
(SE)	0.27	0.37	0.33
% High math	32.9	33.7	31.9
% Low math	12.0	10.4	13.0
% ELL	2.5	2.1	2.8
% special education	7.6	5.2	8.8
% repeated a grade	9.5	6.9	10.9

Note: based on an analytic sample of approximately 12,900 students linked to math teachers in public schools.

In the remainder of the results section, the results of the multilevel analyses are presented in order of the research questions.

Research question 1: Do the odds of having a “qualified” mathematics teacher differ based on student background characteristics?

The results of the analyses investigating the relationship between students' demographic background and the likelihood of having a qualified math teacher are presented in Table 2. All independent variables shown in Table 2 were estimated as fixed effects, centered around the mean for the entire sample. Socioeconomic status (SES), the only continuous variable in these models, was standardized ($M = 0$, $SD = 1$); all other variables are dichotomous.

Equitable access to qualified teachers would be indicated by results showing no relationship between student characteristics and odds of having a qualified teacher. Although the

descriptive results in Table 2 indicated students with qualified teachers differed from students with less qualified teachers along the dimensions of race and socioeconomic status, the multivariate results indicate that within schools, the odds of having a qualified mathematics teacher is unrelated to students' demographic characteristics. Females, minorities, and English language learners are no more or less likely to have qualified teachers compared to males, non-minorities, and non-English language learners. Student SES is also unrelated to access to qualified teachers within schools.

Table 2. Within-School Models: Student Demographics (Odds Ratios [SE])

	Model 1 Female	Model 2 Race	Model 3 SES	Model 4 ELL
Intercept	0.482 [0.212]	0.492 [0.213]	0.489 [0.211]	0.481 [0.212]
Female	0.983 [0.098]			
Black		0.848 [0.143]		
Hispanic		0.883 [0.099]		
Asian		1.000 [0.226]		
Other		0.927 [0.148]		
Socioeconomic status			1.081 [0.054]	
ELL				0.829 [0.215]
<i>Variance Components Table</i>				
Intercept	4.263***	4.248***	4.224***	4.258***
<i>Reliability</i>				
Intercept	0.850	0.849	0.849	0.850

Note: analyses weighted by W1MATHHTCH at Level 1, and by W1SCHOOL at Level 2. Models control for locale and region at level 2.

While student demographic characteristic are unrelated to odds of having a qualified teacher, as seen in models 1 through 4 in Table 3, certain indicators of students' academic background significantly predict students' odds of having a qualified teacher. Special education students are less likely to have qualified teachers (a 34% decrease in the odds of having a qualified teacher), as are students enrolled in low-level math courses; being in a low level math

course is associated with an 31% decrease in the odds of having a qualified teacher. In contrast, students enrolled in high-level math courses and students who had repeated a grade were no more or less likely to have qualified teachers relative to their peers.

In model 4, I find that math achievement has a significant main effect on odds of having a qualified teacher. Compared with students with average math achievement, odds of having a qualified teacher are 1.15 times greater for students whose math achievement is one standard deviation higher than average. I also find that the relationship between math achievement and odds of having a qualified teacher varied significantly across schools. That is, in some schools students' math achievement was more strongly related to their odds of having a qualified teacher than in other schools. Schools in which the relationship is weaker provide more equitable access to qualified teachers along the dimension of prior achievement, in the sense that higher and lower achieving students have equivalent odds of having a qualified teacher. It is possible that school context or working conditions could explain some of the variability in the relationship between students' math achievement and their odds of having a qualified teacher.

Table 3. Within-School Models: Academic Background (Odds Ratios [SE])

	Model 1 SpecEd	Model 2 Repeat	Model 3 Hi/Lo	Model 4 IRT	Model 5 Full
Intercept	0.477 [0.212]	0.485 [0.211]	0.481 [0.215]	0.488 [0.194]	0.493 [0.197]
Female					0.978 [0.088]
Black					0.898 [0.136]
Hispanic					0.967 [0.086]
Asian					1.003 [0.213]
Other					0.968 [0.142]
SES					1.036 [0.049]
ELL					0.881 [0.183]
Spec. ed.	0.660** [0.210]				0.793 [0.174]
Repeater		0.847 [0.137]			0.979 [0.124]
High math			0.982 [0.181]		0.896 [0.177]
Low math			0.691* [0.159]		0.795~ [0.129]
Math IRT				1.145** [0.052]	1.105~ [0.057]
<i>Variance Components Table</i>					
Intercept	4.299***	4.250***	4.285***	4.388***	4.408***
Math IRT score				0.442***	0.427***
<i>Reliability</i>					
Intercept	0.850	0.849	0.850	0.847	0.847
Math IRT score				0.380	0.371

~ p < 0.10 * p < 0.05 ** p < 0.01 *** p < 0.001

In the full within-school model (model 5), two of the three academic indicators continue to be significant predictors of students' access to qualified teachers. Students with higher math achievement are more likely to have a qualified math teacher, and even after controlling for math achievement, a student is significantly less likely to have a qualified teacher if he or she is enrolled in a lower level math class. Being classified as special education is not a statistically significant predictor of odds of having a qualified math teacher after controlling for all other student demographic and academic variables. Residual variances, shown at the bottom of Table 1, indicate that even with student-level statistical controls in the model, significant between-schools variability remains in the adjusted intercept as well as the math achievement slope. This

suggests that school characteristics may be useful predictors of both the odds of having a qualified teacher, and the relationship between math achievement and odds of having a qualified teacher.

Research question 2: Are students in schools with less favorable demographic characteristics (e.g. schools serving predominantly lower-achieving students of lower socioeconomic status) less likely to have qualified teachers relative to students in schools serving more advantaged populations?

The descriptive results suggest that school demographics are related to students' odds of having a qualified high school math teacher. Approximately 46% of students in public schools that fall into the lowest quintile of socioeconomic status have a teacher with such qualifications, while 54% of students in schools in the top quintile of SES have teachers meeting these qualifications. The multivariate findings regarding the relationship between school demographic characteristics and student access to qualified teachers are presented in Table 4. Because the fixed effects changed very little from the within-school models, they are not reported in the between-school models; I focus on the school-level effects on the intercept (odds of student having a qualified teacher).

While racial composition of schools is unrelated to students' odds of having a qualified teacher, school social composition is strongly related to the outcome, such that students in schools serving more affluent students are more likely to have a qualified math teacher. Specifically, for every standard deviation increase in school average SES, a student's odds of having a qualified teacher increase by 1.48. In other words, 9th grade students in these schools have nearly a 50% increase in the odds of having a qualified math teacher. School average math achievement in 9th grade is unrelated to students' odds of having a qualified math teacher. Results are unchanged in the model that controls for all three features of schools. The change in

between-school variance components (from the bottom of Tables 3 and 4) indicates that the model including school demographic characteristics explains 23% of the between-school variation in students' access to qualified teacher that remained after controlling for student characteristics.⁷

Table 4. Between-School Model: School Demographic Characteristics

	Model 1 %Minority	Model 2 SES	Model 3 Math IRT	Model 4 Full
Intercept	1.033 [0.220]	1.005 [0.208]	0.918 [0.204]	0.586 [0.222]
High minority	0.761 [0.270]			0.871 [0.271]
SES		1.322* [0.115]		1.483** [0.149]
Average Math IRT			1.095 [0.117]	0.869 [0.152]
<i>Variance components table</i>				
Intercept	5.609***	5.545***	5.633***	4.271***
Math IRT	0.390***	0.391***	0.389***	0.429***
<i>Reliability</i>				
Intercept	0.878	0.876	0.878	0.841
Math IRT	0.368	0.368	0.367	0.372
~ p < 0.10	* p < 0.05	** p < 0.01	*** p < 0.001	

Note: School socioeconomic status is created by aggregating the socioeconomic status derived with locale from the student file, then standardizing the aggregated value so that the coefficient is in standard deviation units. High-minority schools are defined as schools with 45% or fewer White students, based on the aggregated proportion of students that identify as White.

Research question 3: Are working conditions related to students' access to qualified teachers? Do school characteristics explain variation across schools in the relationship between student background and the odds of having a qualified teacher?

Table 5 shows the relationship between school working conditions and average socioeconomic status. Consistent with theory and prior research, I find that in most cases, working conditions are perceived more favorably in schools serving students from higher socioeconomic background compared to schools serving socioeconomically disadvantaged

⁷ The proportion of variance explained is the difference between the full level 1 model, which included regional and locale variables at level 2, and the between-school model controlling for school demographics. While region and locale were significant predictors of the outcome, they are not the focus of the study so the proportion of variance explained by the between-schools demographic model is net of the explanatory power of these variables.

students; the differences are statistically significant for all working conditions except autonomy. The only exception is planning time: a greater proportion of math teachers in low SES schools reported having adequate planning time relative to teachers in high SES schools ($p < .10$).

Table 5. School Working Conditions by Average Socioeconomic Status

Working Conditions	High SES	Low SES
Principal support	0.32	0.09
Resources & facilities	0.20	-0.34
Math teacher expectations	0.50	0.11
Collective responsibility	0.75	0.02
Student problems	-0.86	0.29
Professional learning community	0.32	-0.21
Planning time	54.9	57.7
Autonomy	68.9	67.2
Professional learning opportunities	67.0	60.9
School climate (administrator perceptions)	0.37	0.23
Principal effort & expectations (counselor perceptions)	0.39	0.04
Teacher effort & expectations (counselor perceptions)	0.40	0.01

Note: Descriptive statistics based on an unweighted sample size of approximately 730 schools. School socioeconomic status categories reflect the highest and lowest quintiles of the aggregated SES variable derived with locale. Descriptive statistics are weighted by NCES-created school weight, W1SCHOOL.

Results that address research question 3 are in Table 6. Only one of the working conditions included in this study had significant main effects on students' access to qualified teachers; several other working conditions are related to the odds of having a qualified teacher contingent upon school context. Counselors' perceptions of principals' effort and expectations has a positive, significant relationship with students' access to qualified teachers. That is, a one standard deviation increase in the extent to which counselors perceive principals as setting high standards, caring about all students, working hard to make sure all students learn, and having high expectations for all students is associated with nearly 40% higher odds of having a qualified high school math teacher, holding all other variables constant. The relationship between school average socioeconomic status and students' odds of having a qualified teacher remains unchanged in the model that accounts for differences across schools in working conditions.

Table 6. Between-Schools Model: Fully Conditional

	Odds Ratio	SE
Intercept	0.687	0.217
City	1.106	0.269
Town	0.743	0.236
Rural	0.905	0.223
Northeast	0.982	0.234
Midwest	1.537	0.265
West	0.755	0.250
High minority	0.722	0.228
SES	1.513**	0.139
School average math	0.816	0.135
Math teacher expectations	1.196	0.144
Student behavior	1.206	0.141
School climate	1.124	0.151
Principal effort/expectations	1.378*	0.129
High autonomy	0.669	0.250
Math*Student behavior	0.800*	0.106
Math*Principal effort/expect	0.817*	0.096
HiMin*Math teacher expect	0.668*	0.184
HiMin*Autonomy	2.200*	0.399
HiMin*School climate	0.643*	0.210
HiMin* Principal effort/expect	0.706~	0.211
<i>Math IRT</i>		
Intercept	1.075	0.057
School average math	0.828**	0.066
Math teacher expectations	1.126**	0.046
<i>Variance components</i>		
Intercept	3.775***	
Math IRT	0.363***	
<i>Reliability</i>		
Intercept	0.825	
Math IRT	0.345	

In developing the within-school model, I found that the relationship between a student's math achievement in fall of 9th grade and his or her odds of having a qualified teacher was positive and significant, but also that the relationship varied across schools. In the between-school model, cross-level interactions revealed that this relationship is particularly strong in schools with lower average achievement (based on 9th graders' fall math scores). That is, in low-achieving schools, high achieving students are much more likely to have a qualified teacher

relative to their low-achieving peers. In high-achieving schools, the opposite is true: high achievers are less likely to have a qualified teacher compared to low-achieving students (see Figure 2).

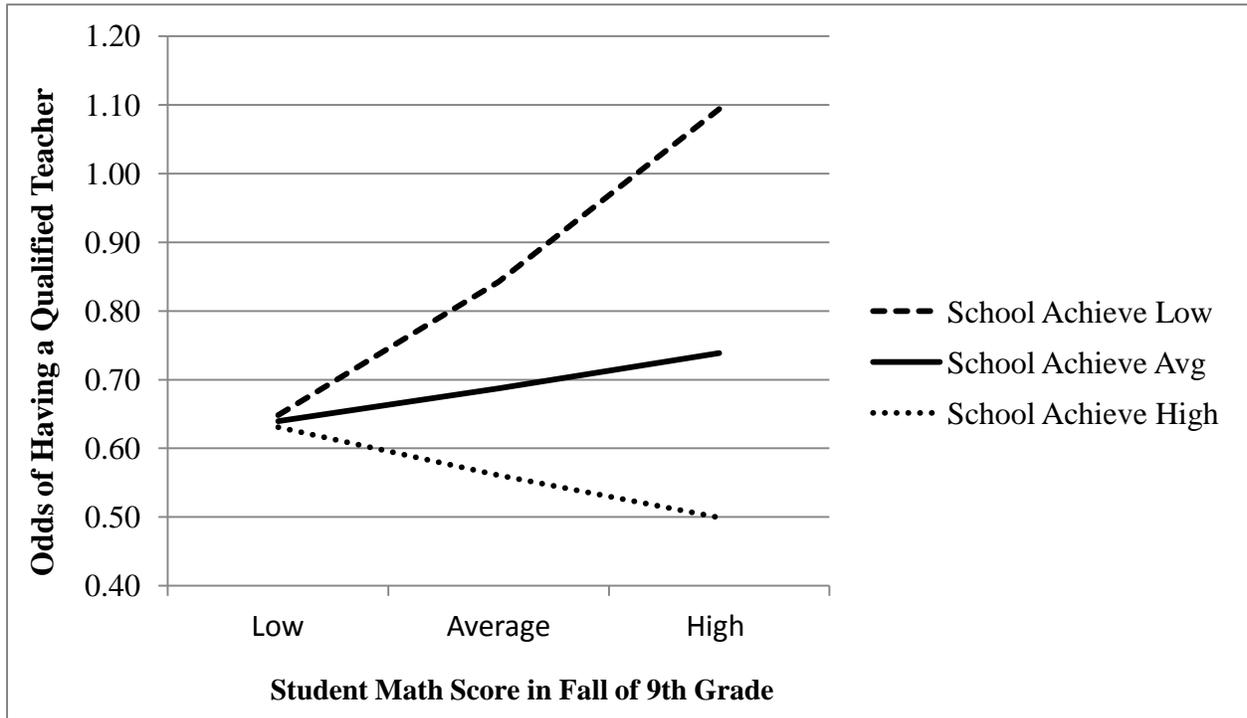


Figure 2: Cross-level interaction: variation in math slope by school average achievement.

Although not displayed here, there is also a significant cross-level interaction between math teachers' expectations and students' odds of having a qualified teacher. In schools in which math teacher expectations are high, the relationship between math achievement and odds of having a qualified teacher is stronger – higher achieving students are more likely to have qualified teachers. In schools where math teacher expectations are average or low, there is less of a relationship between student's fall 9th grade math score and the odds of having a qualified teacher.

As seen in Table 6, several significant interactions exist between working conditions and school context. Significant interaction terms indicate that the effect of certain working conditions on the odds of having a qualified teacher differs according to (1) whether the school serves a high proportion of minority students and (2) school average math achievement in the fall of 9th grade. Figures 3, 4 and 5 are included to facilitate the substantive interpretation of numerical interaction terms from table 6. Results are sums of the main effects for working conditions and any relevant interaction terms (Aiken & West, 1991; Cohen et al., 2003).

Relationships between the outcome and 1) teachers' perceptions of autonomy, 2) math teachers' expectations, 3) counselor's perceptions of principals' effort and expectations, and 4) administrators' perceptions of school climate are all contingent upon whether schools serve a high proportion of minority students. Specifically, in schools with low proportions of minorities (on the left side of Figure 3), higher ratings of principal effort and expectations, math teacher expectations, and school climate are associated with better odds of having a qualified teacher, although greater autonomy is not significantly associated with the odds of having a qualified teacher. In contrast, students in high minority schools have greater odds of having a qualified teacher when teachers perceive having greater autonomy, but are no more likely to have a qualified teacher when principal effort and expectations are higher, and have lower odds of having a qualified teacher when math teacher expectations and school climate are more highly rated. Thus, positive working conditions appear to benefit students differentially depending on the racial composition of their school.

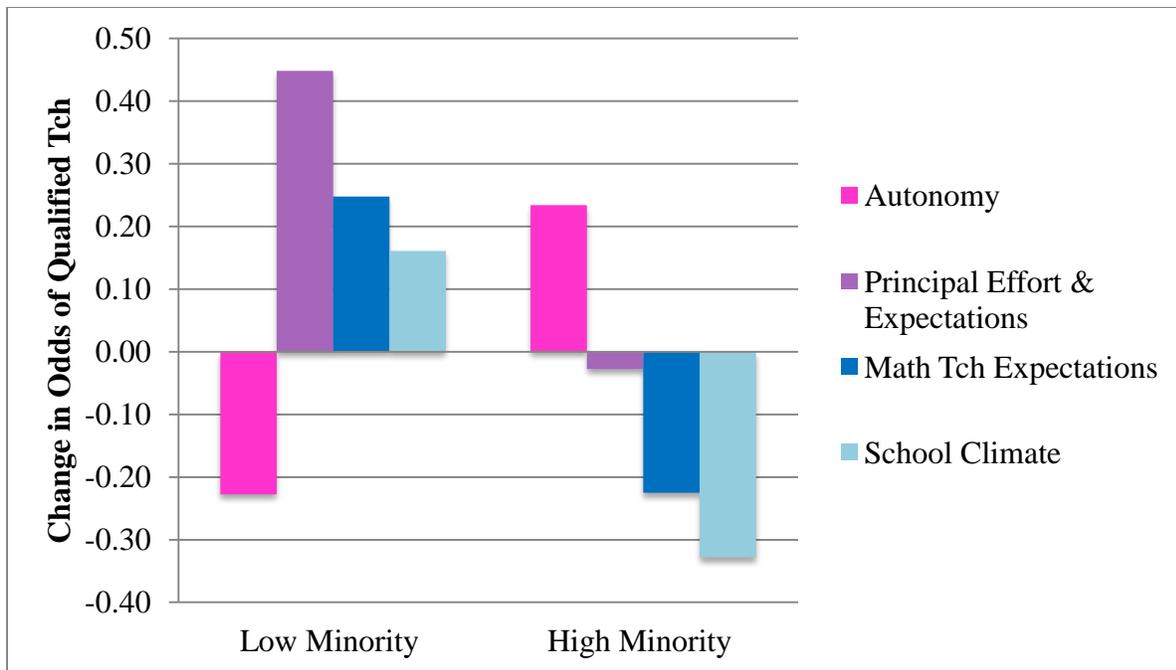


Figure 3: Differential influence of working conditions by proportion of minority students in the school.

School average achievement is another contextual factor that influences the relationship between certain working conditions and students' access to qualified teachers. Specifically, the relationships between the outcome and 1) counselor's perceptions of principal effort and expectations and 2) teachers' perceptions of student behavior are both contingent upon average achievement. In Figure 4, we see that in schools with poor student behavior, the odds of having a qualified teacher are pretty similar regardless of the average math achievement of incoming 9th graders. However, high and low achieving schools diverge as student behavior improves. In low-achieving schools, better student behavior is associated with better odds of having a qualified teacher, but there is no such relationship in high-achieving schools.

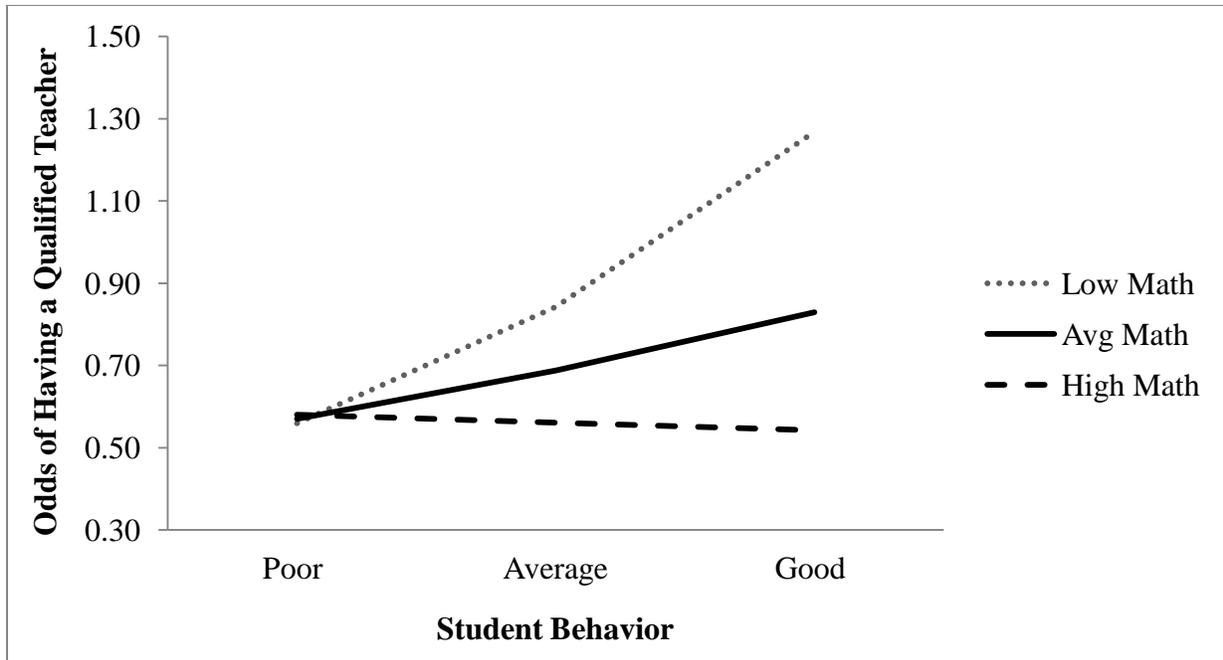


Figure 4: Differential influence of student behavior by average math achievement of 9th graders.

A similar pattern is seen with regard to counselors’ ratings of principal effort and expectations. In schools in which principals are viewed as having low effort and expectations, the odds of having a qualified teacher are similar regardless of the average achievement of incoming 9th graders. However, as perceptions of the principal improve, students in schools with low-achieving 9th graders benefit – the odds of having a qualified teacher increase, whereas the odds of having a qualified math teacher in the schools with higher achieving 9th grade students appear unaffected by principal effort and expectations (see Figure 5).

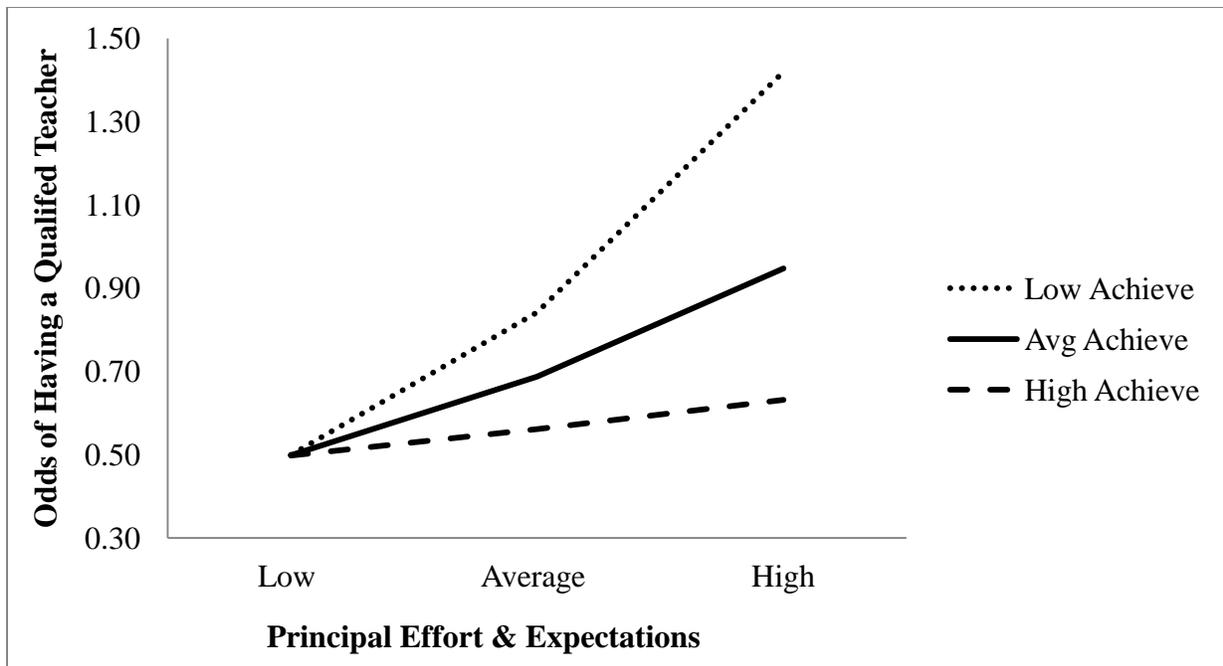


Figure 5: Differential influence of principal effort and expectations by average math achievement of 9th graders.

Discussion

This study is intended to shed light on the extent to which students have access to teachers with qualifications deemed relevant to student achievement, using data collected 7 years after the passage of NCLB. Despite numerous policy efforts of the past decade to ensure students equitable educational opportunities, inequity in student access to qualified teachers continues to occur both within schools, along the dimension of student achievement and between schools, as a function of school average socioeconomic status. I find no significant evidence of disparities in access to qualified high school math teachers by student race, either within or between schools. While some working conditions are associated with student access to qualified teachers, the relationships are often contingent on school context.

Consistent with prior work on the link between students' academic backgrounds and teacher qualifications (e.g. Oakes, 1990; Kelly, 2004), students enrolled in lower-level math courses are less likely to have teachers with qualifications that are associated with teacher effectiveness. This relationship holds even after controlling for students' math achievement. Also consistent with studies of assignment of students to teachers (Feng, 2010; Kalogrides, Loeb & Béteille, 2011), higher-achieving students have greater access to qualified teachers than their lower-achieving peers in the same school. Cross-level interactions indicated that this positive matching (pairing of high-achieving students to more qualified teachers) is especially strong in low-achieving schools. Although positive matching may be considered a defensible practice to the extent that it maximizes student outcomes, inequitable access to qualified teachers to students may diminish the prospects of low-achieving 9th grade students catching up during their high school years.

Since most administrators have little discretion over teachers' salaries, they might rationally choose to award teachers with desirable teaching assignments in an effort to retain favored teachers. Such well-intentioned strategic assignment of teachers, which is a potential explanation for the results in this study, may inadvertently create inequity in access to educational resources. If the relationship between teacher quality and student achievement is stronger for low-achieving students, as Babu and Mendro (2003) found, assigning more qualified teachers to higher-achieving students will be an inefficient use of human capital resources. In fact, Loeb, Kalogrides and Béteille (2011) find that more effective schools provide more equitable class assignments to novice teachers. It may be difficult for administrators to give up offering high-quality teachers the "perk" of more advanced classes, as any administrator who chooses not to offer such perks risks losing teachers to nearby schools where preferences are

honored. Thus, school district leaders and policymakers might look for ways to encourage schools to bolster low-achieving students' access to qualified teachers.

Prior research indicates that the demographic composition of schools is associated with teacher retention and attrition (Hanushek, Rivkin & Kain, 2004; Scafidi, Sjoquist & Stinebrikner, 2007; Ingersoll & Perda, 2010), such that schools with greater proportions of minority, low-income, and low-achieving students have higher rates of attrition. Consistent with what is suggested by prior research, students in schools with lower average socioeconomic status are less likely to have a qualified math teacher. However, in the current study, neither average math achievement nor high minority enrollment explained differences *between* schools in the odds of having a qualified high school math teacher. Among 9th grade public-school math students, achievement indicators appear related to students' odds of having a qualified teacher only *within* schools and race does not appear to be a significant factor either within or between schools. It is unclear whether this discrepancy reflects changes in patterns of teacher attrition, differences in regional vs. national samples, or if perhaps schools serving high proportions of minority and low-achieving students do have higher attrition but are able to find qualified replacements.

A considerable literature on teacher retention has shed light on the types of working conditions teachers find desirable. Several studies have identified school leadership as a particularly salient element of school working conditions when it comes to teachers' career decisions (Ladd, 2009; Johnson, Kraft & Papay, 2012; Boyd et al., 2011). The findings of the current study are consistent with the notion that school leadership is a critical factor; counselors' perceptions of principals as hard-working school leaders who set high expectations for all students are a significant predictor of whether students have access to a qualified teacher.

However, it is not clear whether this is because qualified math teachers are attracted to schools with these types of principals, or whether such principals are particularly effective at hiring and retaining qualified math teachers.

Some researchers have suggested that working conditions as amendable to policy solutions, and that improving organizational conditions will better position schools to attract and retain qualified teachers (Ingersoll & May, 2012; Johnson, Kraft & Papay, 2012). In the current study, only one of the 12 working conditions had a significant main effect on student access to qualified teachers, and it is an open question as to whether or to what extent principals' efforts and expectations can be altered via policy solutions. Furthermore, although prior work by Loeb, Darling-Hammond and Luczak (2004), Grissom (2011), and Johnson, Kraft and Papay (2012) indicated that accounting for working conditions can reduce the observed relationship between school demographics and teacher turnover, I did not find evidence to suggest that stronger working conditions can weaken the relationship between school socioeconomic status and student access to qualified teachers. Inequities in access to such teachers due to social stratification persist even after accounting for a variety of working conditions.

However, I did find a number of significant interactions indicating that the relationship between working conditions and student access to qualified teachers often depends on various aspects of school context. Seeing as the relationship between working conditions and access to qualified teachers varies as a function of school context, a one-size-fits-all approach in which specific working conditions are targeted for improvement is unlikely to succeed across all schools. Schools or districts that struggle to attract and retain qualified staff might begin by

conducting a needs analysis, investigating the current state of working conditions and surveying staff as to which conditions matter most in a particular school environment.

Limitations

There are several limitations to the generalizability and validity of the conclusions of this study. First, generalizability of this study is limited to 9th grade students attending public schools and enrolled mathematics courses in the United States. Students' access to high-quality middle school or elementary school teachers, or to high-quality high school teachers of different subjects, may exhibit different patterns than seen here. Secondly, it is possible that unobserved differences between students (such as behavior of individual students) or schools (such as salary differentials) may partially explain the observed relationships between the independent variables examined and students' access to qualified high school math teachers. Finally, because this is a correlational study based on cross-sectional data, it is inappropriate to draw causal inferences from the results.

Nevertheless, the current study provides valuable information about the relationships between student and school characteristics and public school students' access to qualified high school math teachers. These analyses make use of a nationally representative sample of 9th grade U.S. public school students as well as a methodology that is 1) appropriate given the nested nature of the data and 2) allows us to explore student access to qualified teachers both within and across schools on a national level. While some prior studies employed nationally representative data (c.f. Ingersoll, 2001; Ingersoll & May, 2012) and others have looked at both within and across school sorting simultaneously (c.f. Clotfelter, Ladd, & Vigdor, 2006), one contribution of this study is that it combines the strengths of prior studies by exploring both within- and across-school sorting using nationally representative data.

Directions for Future Research

In light of the differences in student access to qualified teachers based on students' academic background, it would be helpful to explore whether the advantages of positive matching between students and teachers outweigh potentially negative consequences. It is also possible that low- and high-achieving students respond differently to teacher qualifications. Some students may benefit more from being paired with a teacher with a stronger pedagogical background, while other students may respond more to content knowledge. Policymakers and school leaders could use such information to optimally match teachers to students to maximize outcomes for *all* students. In addition, given that students in low-income schools seem to be at a particular disadvantage with regard to equitable educational opportunities, future work might investigate whether certain conditions enable low-income schools to attract and retain qualified teacher. Given the relative importance of school leadership in this and other studies, future studies focusing on principals may shed more light on how positive leadership functions to enhance students' access to qualified teachers.

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