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Do Teacher Credentials and Characteristics Impact Teacher Effectiveness in High School Economics?

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Abstract:

We use student-level administrative data from Georgia to examine how teacher characteristics affect student learning. We develop two models: First, we examine returns to activities often linked to teacher effectiveness – experience, advanced degrees, National Board certification, and in-service workshops. Second, we investigate the importance of having teachers share characteristics with their students. Overall, like many studies before us, we find no systematic link between any of the teacher characteristics and better student outcomes.

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Introduction

The teaching profession has a special place in society. The shaping of young minds is more important now, if possible, than ever before because global markets now demand and reward intellectual contributions more handsomely than physical ones. Unfortunately, it is difficult to systematically analyze what makes for a good teacher. And, as states and local school boards cut education budgets it becomes more important to get the most out of the remaining dollars allocated to schools. But, it has always been difficult to untangle the many confounding elements that combine to create a quality teacher. Personal characteristics combine with investment in human capital which combines with the school environment to create an educational experience for students. And student characteristics can either amplify or conceal the efforts of teachers and school administrators. But, in today's educational environment people – taxpayers, primarily – want to be able to quantify what makes for a good teacher in order to reward good teachers and release ineffective teachers. Often teachers are simply rewarded based on their time in the classroom and the amount of additional schooling, as measured by the attainment of advanced degrees, to determine teacher pay. These traditional measures, however, do not seem to sufficiently translate to better teachers in any systematic and uniform way. Therefore, many researchers from many fields of study have endeavored to pin down relative importance of different inputs into teacher quality.

A tangential issue revolving around teacher and student characteristics is whether or not students do better when they have a teacher who has the same gender or ethnicity. A concern over a lack of diversity in some areas, particularly STEM (Science, Technology, Engineering, and Mathematics) areas has led to programs to encourage women and minorities to train for teaching jobs. Some have postulated that by encouraging women and minorities to fill teaching jobs in these areas, girls and minority students would likely benefit.

Our data allow us to address both of these questions. First, we add to the literature in an examination of student outcomes on a state-mandated, standardized test in economics that follows a required high school economics course in Georgia public schools. Our data match student test scores to rich student-level administrative data and match student observations to teacher data. We analyze the impact of teacher characteristics including achievement of advanced degrees, National Board certification, and years in service as well as attendance to in-service workshops intended to provide teachers with economic content knowledge specifically designed to help them teach to the Georgia curriculum. We control for student characteristics and apply a school level fixed-effect model to control for differences between schools that are unlikely to change over the time span of our data. We also employ a teacher level fixed effects model to investigate the importance of unobserved, time invariant teacher characteristics. Our findings are largely consistent with past findings. We find some evidence that early teacher experience improves teacher effectiveness and that graduate degrees confer some positive returns to the teachers who obtain them. Likewise, we find National Board certification is correlated with stronger student test scores in economics. There is also some evidence for benefits to in-service learning. However, when we control for teacher and school fixed effects most of the benefits of measurable facets of teacher quality become statistically no different from zero. That is to say, there is not an identifiable policy variable available upon which one might rationally base teacher salary in our analysis. It appears that unique invariant characteristics underlie most of the differences between the teachers in our sample.

We also find, when matching student characteristics to teacher characteristics, only some support for the hypothesis that students thrive when they share personal characteristics with their teacher. Girls do seem to do better with female teachers and African American students seem to do better with African American teachers. Other student/teacher pairings do not seem to improve student performance significantly.

Our study is presented as follows: The next section provides background concerning past findings about what makes for an effective teacher and why some believe it is desirable to have teachers who share certain characteristics with their students. The subsequent section describes our data. The fourth section provides and empirical model with which we analyze our data. Following we provide an analysis of our results and conclude.

Background

Teachers are recognized as the linchpin between community expenditures on education and student performance. No amount of spending will improve student outcomes if teachers do not put the resources to good use. Therefore, any discussion concerning the best way to allocate a school budget should concern what makes for a good teacher. There is, however, little agreement on this subject. Research in the field of education has failed to put its collective finger on any characteristics that systematically identify good teachers. Economists have, likewise, failed to provide any policy recommendations that would unequivocally improve teaching.

There is a common list of characteristics researchers examine – primarily because they are relatively easy to observe and states have used them at least in part to determine teacher salaries under the assumption that they correlate with teacher effectiveness. This list includes years of experience, advanced degrees obtained, and teacher certification at both the state and national level. We add to the list content specific in-service training. Most research that attempts to explain student gains in knowledge utilize some combination of these input measures to control for the quality of teachers.

Years of Experience:

Most school systems reward teachers for years of experience. In Georgia, teachers receive increases in their pay grade almost every year from their third year to their 8th year then every other year until they complete 20 years of service. Paying based on years of service assumes that years in service is a proxy for a steady accumulation of human capital gained over time. Very few studies concur with this assumption. Rockoff (2004) finds evidence that years of experience confer fairly small but steady increases in teacher effectiveness for reading comprehension for elementary school age children. But he does not find similar evidence for teachers of mathematics. The consensus appears to be that after the first few years of service, teachers gain little if any additional effectiveness that can be attributed directly to time served. Kane et al. (2006) and Clotfelter et al. (2007a, 2007b) find increases in teacher effectiveness in the early years of the teacher's career but decreasing gains (but still positive and statistically significant) as experience increases. Rivkin et al. (2005) find that during the first five years mathematics teachers gain some effectiveness as they gain experience. But afterwards there is no evidence of additional effectiveness. Grissom and Strunk (2012) take this as evidence for front-loading teacher salaries to reward them for early gains in effectiveness and provide an incentive to retain teachers who demonstrate classroom effectiveness.

Degrees Obtained:

A second formulaic way in which teacher pay is determined is to incorporate degrees earned as a factor of base pay. The standard human capital models hold that additional years of education should translate into additional productivity. However, as more school districts began to reward additional degrees in the pay schedule, more degrees became available through more avenues for teachers. Not all degrees are of equal value. Consequently, the research on the subject has increasingly found advanced degrees provide little guarantee of increases in teacher effectiveness. For example, looking at the proportion of teachers in 4th-7th grade classrooms with advanced degrees, Rivkin et al. (2005) find no statistically significant evidence that an increase in the proportion of teachers with advanced degrees improves student performance on either math or reading scores. Clotfelter et al. (2007b) report very similar results when looking at individual teachers. In short, the research indicates that advanced degrees do not generally improve teacher performance.

Certification:

One approach to acknowledging teacher quality is to reward a teacher once he or she has obtained external certification. Certification can occur at the state or national level. Goldhaber and Brewer (2000) find evidence to support that with standard (state-level) certification perform better in the math and science classroom as compared to teachers with no certification. Kane et al. (2006) find virtually no impact from state-level certification. Primary among certifying organizations is the National Board for Professional Teaching Standards (NBPTS) which offers National Board certification for teachers who can demonstrate a mastery of their craft. Clotfelter et al. (2007b) isolate the effectiveness of National Board certification as an *ex post* measure of teacher quality. They find it does tend to identify better teachers – that is the students of teachers who are Board certified outperform their peers in math and reading by a statistically significant amount.

In-Service Training:

An additional avenue for economics teachers to build human capital short of earning additional degrees or certification is to attend workshops that offer specific economic content. In-service training is one way teachers can acquire such training. The Georgia Council on Economic Education (GCEE) offers teacher workshops on topics directly linked to Georgia's Performance Standards in economics. There is evidence that GCEE workshops help teachers in the high school economics classroom. Swinton et al. (2007), Swinton et al. (2010), Swinton et al. (2012), and Swinton and Scafidi (2012) all find that the students of teachers who attend particular individual topic workshops score better on Georgia's EOCT than students who have not attended such workshops. In this study we take a broader approach by examining workshop attendance in general. By taking this broader approach and including all workshops rather than just specific workshops we run the risk of muting the estimation of the effectiveness of in-service training.

One of the problems with relying on observable differences in teacher inputs is that there may be systematic differences among teachers that drive some to seek out ways to improve their teaching performance while others undertake little effort to accumulate additional human capital. Without a means for addressing this potential misspecification problem, a model of teacher effectiveness is likely to overstate the importance of observed characteristics such as advanced degrees and National Board certification. To account for this possibility many studies incorporate a teacher fixed effects approach to modeling student outcomes. Rockoff (2004), Rivkin et al. (2005), and Clotfelter et al (2007a, 2007b) each incorporate this approach.

While specific teacher characteristics are important, so is the learning environment itself. Heck (2007) focuses on various school characteristics that impact student outcomes. He pays special attention to the organizational principles schools use. But, because in many cases, ours included, the time frame covered by data is too short to observe variation with schools, there is little to be gained by examining the different school qualities that may vary across schools. Therefore, like most of the other studies cited here we incorporate a school-level fixed effects model to capture school specific qualities that may either aid or hinder student learning.

Finally, it is important to capture the difference students bring to the classroom. Student characteristics such as gender and ethnicity have consistently been shown to impact estimated test scores. To isolate the impact of differences in teacher characteristics on students, two different impacts must be considered. First, one must control for students' preexisting knowledge. If a pretest in the same subject is available, it can serve as a hallmark to identify what a student understands prior to taking a class. Rivkin et al. (2005) and Clotfelter et al. (2007a, 2007b) both have access to tests in the same subject areas taken prior to the class outcome they investigate. We control for pre-existing student aptitude in economics by using a previous end-of-course test in geometry. Studies such as e.g. Ballard and Johnson (2004) and Swinton et al. (2012) have shown the efficacy of such an approach. It is also important to control for student differences that might contribute to the learning process. Typically, educational production functions (for example, Bosshardt and Watts 1994 or Swinton et al. 2010) include measures such as gender, ethnicity, a measure of available economic resources, and any other variables that may improve or impede a student's ability to acquire knowledge.

Second model:

As schools cast around for ways to improve the learning environment, some have suggested that in addition to having teachers with more experience and more training schools should try to hire teachers who better mirror their students – schools should have more women and more minorities in front of the class. We have an opportunity to investigate the link between student and teacher pairings on gender and a few racial categories.

Both links have been studied fairly extensively using the National Education Longitudinal Study of 1988 which provides a rich matching of student and teacher characteristics and the Project STAR data (Student Teacher Achievement Data) which incorporates random classroom assignment to investigate the effects of class size on student outcomes. Recent interest in improving STEM (Science, Technology, Engineering, and Math) education has led to greater interest in Gender has been studied more thoroughly than the impact of racial differences, particularly in the context of STEM subjects and in economics. These subjects have received more scrutiny because traditionally there have been fewer women entering into these fields.

Female students and Female teachers

Bettinger and Long (2005) examine the role women play as mentors to future female economists in colleges. They find that female instructors make up a far smaller percentage of economics faculty than the percentage of female students majoring in economics. They find that having more women in underrepresented departments can increase the likelihood of female students taking more classes within those departments. Dee (2007) offers a careful analysis of the National Education Longitudinal Study of 1988 in which he concludes that there is some reason to be concerned about the gender pairing of teachers to students. In his analysis female teachers appear to exert a negative influence on male students in English courses and both male and female students in mathematics. He suggests that he finds these results in part because he controls for student fixed effects. He suggests that male students who struggle in school are more likely to be assigned to male teachers. Therefore, the lack of effect found in studies such as Ehrenberg, Goldhaber, and Brewer (1995) are due to misspecification issues.

Minority Students and Minority teachers

For years it was speculated that that minority students would benefit if they were taught by someone who shared their ethnic background. Testing such a hypothesis has proven difficult due to specification problems. Dee (2004) makes use of the random assignment of the STAR data set to provide fairly strong evidence that both white and African American students benefit from being paired with a teacher of the same race. Other researchers have largely failed to find the same effect. For example, Howsen and Trawick (2007) reconsider Dee's findings using the same data. Once they control for student innate ability (as measured by a cognitive skills index available within the data set) they find that the importance of matching on race becomes statistically irrelevant to the model.

Data

As part of its response to No Child Left Behind legislation (Public Law 107-110, 115 Stat. 1425) and in part due to Georgia's A+ Education Reform Act of 2000 (O.C.G.A §20-2-281), the Georgia Department of Education (GaDOE) instituted a series of high school subject end-of-course tests (EOCT). All public high school students must take these tests in order to graduate. The tests are high stakes tests in that they constitute 15% of the course they represent.[1] For this study we focus on two of these tests – highs school geometry and economics. The economics EOCT represents our dependent variable. The geometry EOCT represents a control variable for student achievement prior to taking economics. While we do not observe student economic knowledge before they take their high school economics class, past studies (e.g. Ballard and Johnson, 2004 and Swinton, Scafidi, and Woodard, 2012) have demonstrated that mathematics knowledge (geometry in particular) is a good predictor of future success in economics.

Georgia's Department of Education links these test results to rich administrative student data. The student data include the student's gender, ethnicity (categorized as Asian, black, Hispanic, native American, white, or mixed race), economic status (whether or not a student receives a free or reduced-price lunch), and disability status (whether or not the student suffers from one or more of a number of physical or mental disabilities). The student data are also linked to a teacher of record for each EOCT.

Teacher data also come from the GaDOE. We use data from the Certified Personnel Index (CPI). The CPI provides teacher information including the teacher's gender, age, ethnicity (categorized as white, black, Hispanic, or other race), degrees earned, whether or not the teacher is National Board certified, and years of experience as described by the teacher's salary step (see Appendix for Salary Step definition). While we also know what school a teacher teaches in we do not use school specific characteristics. Instead, we utilize a school-level fixed effects approach as explained in the description

[1] For the period covered by our data the EOCTs constituted 15% of the student's course grade. They now count for 20% of the student's course grade. For a further description of the tests see Swinton et al. 2010.

of the model. We cannot use both, as the time period of the study is too short for most of the school characteristics to change in any significant fashion.

Finally, we include information as to whether or not teachers have attended in-service workshops conducted by the Georgia Council on Economic Education (GCEE). Swinton et al. (2010) shows that the students of teachers who have attended GCEE workshops tend to perform better on the economics EOCT than other students other things being equal. GCEE provides in-service workshops to well over a thousand teachers each year. The workshops are provided at no cost to teachers and cover all facets of the state curriculum (for a more detailed description of the nature of the workshops see Swinton et al., 2010). GCEE has kept computerized records of all teachers who have participated in their workshops since 1990. We match the teachers in the CPI data set to GCEE data. We then create a dummy variable that is equal to 1 if the teacher of record has taken any GCEE workshops and 0 otherwise. In the dataset, 42.6 percent of teachers have attended GCEE in-service workshops at some point.

We utilize four years of data covering the fiscal years 2006 through 2009. While we have access to all public school students in Georgia, our data has a few limitations. First, we use only those student observations that we can match geometry EOCT scores that were prior to their economics EOCT scores. We do not have matches for all students for a couple of reasons. In the early years of the testing environment those who took the economics EOCT may have had geometry before the various EOCTs were first administered. Furthermore, not all schools schedule economics after geometry. There are a few schools that teach economics in the freshman or sophomore years. In these cases, a prior geometry EOCT score is not available. Second, if we do not have data on the characteristics or credentials of a student's teacher, then that student's observation is not used.

As a result we have 2,237 teachers in the data set matched to 197,886 student observations. Rather than use raw economics EOCT scores as our dependent variable we normalize the scores by constructing Z-scores. The Z-scores for each test score equal to: $((x_{it} - \mu_t)/\sigma_t)$, were x_{it} is the individual student's economics EOCT score at time t, μ_t is the mean of the test scores in year t, and σ_t is the standard deviation of the test score for year t. As a result the mean is 0 and the standard deviation is 1. As the test may change over time, this normalization is necessary to make the test results comparable from year to year.

A summary of the student and teacher data appear in Table 1.

[Table 1 about here]

The majority of the students in the sample are female (53%) while the majority of the teachers in the data are male (67%). 47% of the students and only 16% of the teachers in the data are nonwhite. 34% of the students in the sample received free or reduced price lunches. The majority of the teachers in the data have an advanced degree (62%), but less than 2% of teachers are Nationally Board certified.

Empirical Model

Model (1): Teacher Human Capital

Like Rockoff (2004), Rivkin, Hanushek and Kain (2005), and Clotfelter, Ladd, and Vigdo (2007) we investigate returns to teacher investment in human capital while focusing on student level data. IN contrast to the above mentioned studies which all examine general reading and mathematics standardized competency test results, we focus on student performance on a standardized test of economic knowledge (the state-mandated EOCT in economics.) All Georgia public school students must take this high-stakes exam upon completing a mandatory high school economics class. We model the contributions of student gains in knowledge by accounting for student characteristics, time-invariant school and teacher characteristics, and, most importantly, changes in teacher characteristics.

One of the often confronted problems with modeling the contributions to student learning is controlling for student knowledge prior to their experience with the teacher. While Rockoff (2004) does not control for prior student knowledge directly, Rivkin et al. (2005) and Clotfelter et al. (2007) do so in different ways. Both studies have measures of achievement in the same test area (math and reading) from previous tests. That is, their data track students' progress on a succession of tests in the two subject areas of interest. Rivkin et al. focus on the change in test scores using a first differences approach. That is, they measure the impact of school, teacher, and student characteristics on the rate of change of test scores. In contrast, Clotfelter et al. use previous test scores as a control variable on the right hand side of their model. Admittedly, this approach is not perfect – such measures may be endogenous to the student's learning process – it is a generally accepted method of controlling for student prior knowledge. The alternative approach, such as Rivkin et al., is not appropriate in our case. Instead of prior test scores in the same subject, economics, we use a related measure of prior student achievement, previous end-of-course test scores in geometry. Therefore, we adopt the Clotfelter et al. approach. Past studies (e.g. Ballard and Johnson, 2004 and Swinton, Scafidi, and Woodard, 2012) have shown that math achievement (geometry in particular) does a good job predicting subsequent success in economics classes. Therefore, we present a modified "value-added" model in which the portion of a student's achievement in an economics EOCT that can be explained by otherwise unobserved abilities to acquire knowledge not attributable to teacher quality is captured by performance on the mandated geometry EOCT.

Other factors that have consistently been demonstrated to impact student achievement are student characteristics such as gender, race, disability status, and poverty status. We control for these characteristics with a series of student demographic indicator variables. Also of interest are the characteristics of the schools in which students learn. If these characteristics change over time (for example, see Heck, 2007, which focuses on school-level resources) quantifying the changes is important. Over a short period of time, however, these characteristics are unlikely to change with enough regularity to allow us to pick up the effects of variations within schools. Therefore, we use a fixed effects approach to capture variations in school characteristics between schools.

Of primary interest in this study are teacher characteristics that contribute to student learning of economics. There are two general types of characteristics we consider – those that are time invariant (at least for the time of the study) and those that do demonstrate sufficient change within the time of the study to allow us to quantify the impacts of the changes. Like school characteristics that do not change over time we can model time invariant teacher characteristics with a vector of teacher dummy variables – or fixed effects. We examine a number of variables that have been thought to impact teacher effectiveness in the classroom. These variables include the number of years of service, whether or not the teacher has an advanced degree, whether or not the teacher is national board certified, and, whether or not the teacher has attended any in-service economics workshops with the Georgia Council on Economic Education. We have found in previous studies (Swinton et al. 2007, Swinton et al. 2010, Swinton et al. 2012, Swinton and Scafidi, 2012) that teacher attendance to such workshops has a positive effect on student learning. With the exception of workshop attendance, each of the variables listed has in one form or another been linked to teacher pay.

The base model takes the form:

$$EconEOCT_i = \alpha GeomEOCT_i + \beta_1 Student_i + \beta_2 VTeacher_j + \beta_3 NVTeacher_j + \gamma NVSchool_n + \varepsilon_{ij.} \quad (1)$$

$EconEOCT_i$ is the normalized test score of student *i* on the economics EOCT and $GeomEOCT_i$ is that student's normalized EOCT score in geometry. The vector of student characteristics ($Student_i$) includes a dummy variable for gender (=1 if the student is female), a series of indicator variables for ethnicity (Asian, black, Hispanic, Native American, and mixed race with white as the omitted variable), poor (=1 if receives free or reduced price lunch), and disability status (=1 if the student is categorized as disabled). The $VTeacher_j$ vector contains teacher characteristics that vary with time. There are four different teacher characteristics that we use to determine the accumulation of human capita. First, we quantify experience with 13 separate pay step qualifications. Each pay step represents an additional one or two years on the job (see the appendix for a definition of the pay steps). We use pay steps as opposed to years of service because in the discussion of the appropriate remuneration for effectiveness it is convenient to compare the points at which a teacher is automatically given a raise to his or her incremental effectiveness at that same juncture. Second, we include a dummy variable that describes whether or not a teacher has earned an advanced degree. Third, we use a dummy variable that signifies whether or not the teacher has earned National Board certification. Clotfelter et al. find evidence that earning National Board certification is positively correlated with teacher effectiveness (although it is difficult to determine if National Board certification is simply a way for better teachers to signal that they are more committed to teaching) but there is little evidence to suggest obtaining advanced degrees improves teacher effectiveness. Finally, we include a fourth teacher characteristic that is relevant for the specific subject of economics. We know if teachers have attended any in-service workshops conducted by the Georgia Council of Economic Education. We include this information with a dummy variable in the model. $NVTeacher_j$ represents a vector of teacher fixed effects dummy variables. $NVSchool_n$ represents a vector of *n* school fixed effects dummy variables to capture the impact of invariant school characteristics that impact student learning. While other work has found specific school characteristics do matter, our time frame is too short to observe any meaningful change in any of these characteristics. Therefore, an examination of the importance of within-school effects is not possible. To show the importance of both teacher level and school level fixed effects, we first present results without either, then we present results with teacher level fixed effects but not school level fixed effects. Following that, we control for school level fixed effects but not teacher level fixed effects. Finally, we present results that control for both.

Model (2): Teacher Demographics

Because we also have some invariant teacher information, gender and ethnicity in particular, we can look at the effect of teacher demographics on student learning. Therefore, we model student performance including teacher demographics. Some research (CITATIONS COMING) has suggested that students respond well to teachers who happen to look like them, so we also include interaction terms that indicate whether or not the teacher and student share the same gender or ethnicity. The second model takes the form:

$$EconEOCT_i = \alpha GeomEOCT_i + \beta_1 Student_i + \beta_2 Teacher_j + \beta_3 Teacher_j Student_i + \gamma NVSchool_n + \varepsilon_{ij.} \quad (2)$$

In this model the vector of teacher variables, $Teacher_j$, represents indicator variables for whether or not the teacher is over 60, whether or not the teacher is black or Hispanic (white being the omitted variable), and whether or not the teacher is female. The vector $Teacher_j Student_i$ represents a series of interaction dummy variables that indicate whether or not student i and teacher j share similar characteristics. The vector consists of 7 separate dummy variables that are meant to capture the effect of female students with female teachers, black students with black teachers, Hispanic students with black teachers, Asian students with black teachers, black students with Hispanic teachers, Hispanic students with Hispanic teachers, Asian Students with Hispanic teachers. The other vectors remain the same as in the first model.

We present the results in two ways.[2] We first present the results omitting the teacher-student interaction variables. This acts as a baseline from which we compare the next set of results. In the second set of results we include the interaction terms as described.

Results and Discussion

The results of the estimation of our teacher human capital model are presented in Table 2. The first

[Table 2 about here]

[2] Unfortunately, the use of teacher and student race interactions required us to drop a very small percentage of the observations in our data (2.3%) due to extremely small cell sizes for some combinations of teacher and student races. These observations were dropped when estimating the baseline and interaction models to make the two sets of results directly comparable.

column of Table 2 contains the results of a simple regression that does not include teacher or school level fixed effects. When teacher and school level fixed effects are not included in the model, we find that students who have a teacher who has attended a workshop score roughly 12% of a standard deviation higher on their economics EOCT exam. We also find that students whose teachers have advanced degrees or are nationally certified perform better than other students. We find very mixed effects for experience, as measured by our pay step variables, some steps are statistically significant and positive, while others steps are statistically significant and negative, and many are not statistically different from zero.

Of course, the exclusion of school and teacher level fixed effects from the model used to estimate the results presented in column 1 means that we do not control for time invariant school or teacher characteristics that could affect student outcomes. In order to address that omission we add school level fixed effect (as presented in column 2), then teacher level fixed effects (as presented in column 3), and finally both school and teacher level fixed effects (as presented in column 4).

As is evidence from the results presented in column 4 of Table 2, after including both school and teacher level fixed effects we find markedly different effects of teacher credentials on student scores on the Economics EOCT. The effect of workshop attendance on student performance becomes statistically insignificant. The effect of a student's teacher earning an advanced degree does not appear to be a statistically significant determinant of student performance on the Economics EOCT. A teacher becoming nationally certified appears to decrease a student's performance on the Economics EOCT by roughly 11% of a standard deviation. And students with teachers who move up a pay step often perform worse than those who do not. This effect is statistically significant for 11 of the 13 pay steps.

In all the iterations presented in Table 2, we find that female, nonwhite, poor, and learning disabled students perform worse than their counterparts. We also find that students who perform better on the Geometry EOCT are likely to perform significantly better on the Economics EOCT.

The change in sign and significance observed for these teacher credential variables appears to be driven by the inclusion of the teacher level fixed effects, as evidenced by the change in effects when comparing columns 3 or 4 to column 2 which only includes school level fixed effects. The finding that teacher credentials generally have either no effect or, in some cases, a negative effect on student performance on the Economics EOCT after including teacher level fixed effects suggest that a teacher's demographics may be a significant determinant of student performance. We present the results of our analysis of the effect of teacher characteristics in Table 3.

[Table 3 about here]

Column 1 of Table 3 contains the results of our analysis of the effect of teacher characteristics on student performance on the Economics EOCT after controlling for school level fixed effects, but excluding student-teacher characteristic interactions. We find that having a teacher that is over 60 years old significantly decreases student performance on the Economic EOCT. We also find that having either a black or Hispanic teacher reduces student performance. Students with a female teacher earn scores on the Economics EOCT that are roughly 7% of a standard deviation higher than students with a male teacher.

It is possible that students of different races and genders may perform differently based on the race or gender of their teacher. For example, it is possible that a female student may perform differently if her teacher is also female. In order to address this possibility we interacted teacher and student race and gender variables. Column 2 of Table 3 contains the results of our estimation of the updated model. We find that female students who have female teachers score 4.3% of a standard deviation higher on the Economics EOCT than do male students with male teachers. Asian students who have Hispanic teachers score 16% of a standard deviation better on the Economics EOCT than do white students with white teachers. The other interactions do not have statistically significant coefficients.

The inclusion of these teacher and student characteristic interactions also changes the interpretation of the effects of our teacher female, teacher black, and teacher Hispanic variables, as well, as the student race and gender variables. The interpretation of the coefficient on our teacher female variable is now the effect of a female teacher on a male student (his score will be roughly 5% of a standard deviation higher) relative to a male teacher with a male student. Likewise, the interpretation of the student female variable is that female students who have male teachers will score 16% of a standard deviation lower than male students with male teachers. The interpretation of the coefficients on teacher black and teacher Hispanic changes to the effects of those teachers on white students relative to white teachers. The coefficients on the student race variables also change such that they should be interpreted as the effect on the Economics EOCT performance of those students having white teachers relative to the effect on white students of having white teachers.

In all the iterations presented in Tables 2 and 3, we find that female, nonwhite, poor, and learning disabled students perform worse than their counterparts. We also find that students who perform better on the Geometry EOCT are likely to perform significantly better on the Economics EOCT.

Taken as a whole our results indicate that both teacher characteristics and teacher credentials significantly affect student performance on the Economics EOCT. In many cases the effect of an increase in a teacher's credentials appears to decrease the performance of his/her students. There also appears to be some evidence that some student-teacher race and gender combinations affect student performance in interesting ways.

Tables

Table 1: Summary Statistics	
A. Student Characteristics	
	Mean (Std. Dev.)
Econ EOCT (z-score)	0.0000 (1.0000)
Female	0.5314 (0.4990)
Asian	0.0352 (0.1844)
Black	0.3595 (0.4798)
Hispanic	0.0544 (0.2267)
Native American	0.0015 (0.0383)
Mixed race	0.0179 (0.1327)
Poor	0.3384 (0.4732)
Disabled	0.0461 (0.2097)
Geometry	615.1913 (30.2521)
B. Teacher Characteristics	
Workshop	0.4263 (0.4945)
over 60	0.0964 (0.2952)
advanced degree	0.6286 (0.4832)
national certification	0.0167 (0.1281)
teacher female	0.3314 (0.4707)
teacher Black	0.1460 (0.3531)
teacher Hispanic	0.0080 (0.0891)
teacher other race	0.0034 (0.0579)
pay step 1	0.0542 (0.2263)
pay step 2	0.0536 (0.2252)
pay step 3	0.0523 (0.2227)
pay step 4	0.0519 (0.2218)
pay step 5	0.0474 (0.2124)
pay step 6	0.0527 (0.2234)
pay step 7	0.0957 (0.2942)
pay step L1	0.0872 (0.2822)
pay step L2	0.0600 (0.2374)
pay step L3	0.0406 (0.1973)
pay step L4	0.0383 (0.1918)
pay step L5	0.0421 (0.2009)
pay setp L6	0.2047 (0.4035)
Sample Size	197,886

Table 2: Model 1: Teacher Credentials

	Simple	School FE	Teacher FE	Teacher and School FE
	Coefficient	Coefficient	Coefficient	Coefficient
Student Characteristics	(Std. Error)	(Std. Error)	(Std. Error)	(Std. Error)
Female	-0.1498	-0.1524	-0.1652	-0.1654
	(0.0033)	(0.0032)	(0.0031)	(0.0031)
Asian	-0.1366	-0.1543	-0.1848	-0.1877
	(0.0091)	(0.0091)	(0.0088)	(0.0088)
African American	-0.2358	-0.2509	-0.2385	-0.2399
	(0.0042)	(0.0047)	(0.0045)	(0.0045)
Hispanic	-0.2119	-0.2272	-0.2081	-0.2077
	(0.0077)	(0.0078)	(0.0076)	(0.0076)
Native American	-0.1152	-0.1224	-0.1316	-0.1354
	(0.0429)	(0.0414)	(0.0400)	(0.0399)
Mixed race	-0.0553	-0.0803	-0.0736	-0.0746
	(0.0125)	(0.0122)	(0.0117)	(0.0117)
Poor	-0.1339	-0.1048	-0.0920	-0.0899
	(0.0040)	(0.0040)	(0.0039)	(0.0039)
Disabled	-0.2598	-0.2757	-0.2119	-0.2097
	(0.0080)	(0.0078)	(0.0084)	(0.0084)
Geometry EOCT	0.0191	0.0188	0.0178	0.0178
	(0.0001)	(0.0001)	(0.0001)	(0.0001)

Table 2: Model 1: Teacher Credentials (continued)

	Simple	School FE	Teacher FE	Teacher and School FE
	Coefficient	Coefficient	Coefficient	Coefficient
Teacher Characteristics	(Std. Error)	(Std. Error)	(Std. Error)	(Std. Error)
Workshop	0.1175	0.0971	-0.0043	0.0071
	(0.0034)	(0.0040)	(0.0068)	(0.0072)
advanced degree	0.0714	0.0719	-0.0047	-0.0050
	(0.0036)	(0.0042)	(0.0122)	(0.0134)
national certification	0.2416	0.2302	-0.0458	-0.1083
	(0.0130)	(0.0149)	(0.0414)	(0.0453)
pay step 1	0.0157	0.0271	0.0101	0.0064
	(0.0085)	(0.0089)	(0.0121)	(0.0127)
pay step 2	-0.0079	0.0268	-0.0242	-0.0190
	(0.0086)	(0.0092)	(0.0133)	(0.0141)
pay step 3	-0.0086	0.0217	-0.0461	-0.0646
	(0.0086)	(0.0093)	(0.0146)	(0.0156)
pay step 4	-0.0231	0.0074	-0.0387	-0.0608
	(0.0087)	(0.0095)	(0.0162)	(0.0176)
pay step 5	-0.0377	0.0083	-0.0582	-0.0719
	(0.0090)	(0.0097)	(0.0180)	(0.0199)
pay step 6	0.0262	0.0524	-0.0463	-0.0598
	(0.0087)	(0.0094)	(0.0194)	(0.0215)
pay step 7	0.0139	0.0527	-0.0573	-0.0785
	(0.0073)	(0.0082)	(0.0205)	(0.0228)
pay step L1	-0.0618	-0.0251	-0.1051	-0.1432
	(0.0075)	(0.0084)	(0.0225)	(0.0249)
pay step L2	-0.0302	-0.0063	-0.1498	-0.1945
	(0.0084)	(0.0095)	(0.0248)	(0.0273)
pay step L3	-0.0533	-0.0141	-0.1815	-0.2405
	(0.0096)	(0.0107)	(0.0275)	(0.0302)
pay step L4	-0.0072	0.0934	-0.1760	-0.2459
	(0.0098)	(0.0110)	(0.0299)	(0.0332)
pay step L5	-0.0701	0.0154	-0.3799	-0.4287
	(0.0094)	(0.0105)	(0.0322)	(0.0361)
pay step L6	-0.0715	-0.0150	-0.3828	-0.4472
	(0.0063)	(0.0073)	(0.0329)	(0.0377)
Teacher FE	No	No	Yes	Yes
School FE	No	Yes	No	Yes
Sample Size	197,886	197,886	197,886	197,886
Adjusted R-squared	0.4678	0.5049	0.5429	0.5448

Table 3: Model 2: Teacher Characteristics and Teacher/Student Interactions

	School FE	School FE and Interactions
	Coefficient	Coefficient
Student Characteristics	(Std. Error)	(Std. Error)
female	-0.1519	-0.1661
	(0.0032)	(0.0040)
Asian	-0.1456	-0.1449
	(0.0091)	(0.0096)
black	-0.2515	-0.2541
	(0.0047)	(0.0049)
Hispanic	-0.2285	-0.2253
	(0.0079)	(0.0083)
poor	-0.1044	-0.1042
	(0.0041)	(0.0041)
disabled	-0.2858	-0.2854
	(0.0079)	(0.0079)
Geometry	0.0189	0.0189
	(0.0001)	(0.0001)

Table 3: Model 2: Teacher Characteristics and Teacher/Student Interactions (continued)

	School FE	School FE and Interactions
	Coefficient	Coefficient
Teacher Characteristics	(Std. Error)	(Std. Error)
over 60	-0.0885	-0.0887
	(0.0064)	(0.0064)
teacher female	0.0710	0.0481
	(0.0043)	(0.0057)
teacher black	-0.0512	-0.0617
	(0.0069)	(0.0110)
teacher Hispanic	-0.1813	-0.1861
	(0.0224)	(0.0311)
Interactions		
Female Student with Female Teacher	--	0.0428
		(0.0068)
Black Student with Black Teacher	--	0.0199
		(0.0127)
Hispanic Student with Black Teacher	--	-0.0233
		(0.0242)
Asian Student with Black Teacher	--	-0.0231
		(0.0326)
Black Student with Hispanic Teacher	--	-0.0125
		(0.0413)
Hispanic Student with Hispanic Teacher	--	0.0135
		(0.0574)
Asian Student with Hispanic Teacher	--	0.1603
		(0.0936)
School FE	Yes	Yes
Sample Size	193,394	193,394
Adjusted R-squared	0.5037	0.5038

Appendix:

Teacher Salary Step	Years of Experience
E	0, 1, 2
1	3
2	4
3	5
4	6
5	7
6	8
7	9, 10
L1	11, 12
L2	13, 14
L3	15, 16
L4	17, 18
L5	19, 20
L6	21+

Source: Georgia Annual/Monthly Salary Schedule

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