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Making a Difference?

The Effects of Teach for America in High School

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Teach for America (TFA) recruits and selects graduates from some of the most selective colleges and universities across the country to teach in the nation's most challenging K–12 schools throughout the nation. TFA has grown significantly since its inception in 1990, when it received 2,500 applicants and selected and placed 500 teachers. In 2005, it received over 17,000 applicants and selected and placed a little over 2,000 new teachers, and the program anticipates expanding to over 4,000 placements in 2010. In total, the program has affected the lives of nearly 3 million students.

The growth of the program alone suggests that TFA is helping to address the crucial need to staff the nation's schools, a particularly acute need in high poverty schools, but TFA is not without its critics. The criticisms tend to fall into two categories. The first is that most TFA teachers have not received traditional teacher training and therefore are not as prepared for the demands of the classroom as traditionally trained teachers. TFA corps members participate in an intensive five-week summer national institute and a two week local orientation/induction program prior to their first teaching assignment.[2] The second criticism is that TFA requires only a two year teaching commitment, and the majority of corps members leave at the end of that commitment. The short tenure of TFA teachers is troubling because research shows that new teachers are generally less effective than more experienced teachers (Rivkin, Hanushek, and Kain, 2005; Rockoff, 2004).

[2] In recent years, TFA corps members have also engaged in on-going professional development activities provided by TFA and whatever other supports school districts provide new teachers.

The research reported here investigates the relative effectiveness (in terms of student tested achievement) of TFA teachers, and examines the validity of the criticisms of TFA. Specifically, we look at TFA teachers in secondary schools, and especially in math and science, where considerable program growth is planned over the next few years. To the best of our knowledge, this is the first study of TFA at the secondary school level.

Using individual level student data linked to teacher data in North Carolina, we estimate the effects of having a TFA teacher compared to a traditional teacher on student performance. The North Carolina data we employ is uniquely suited for this type of analysis because it includes end of course testing for students across multiple subjects. This allows us to employ statistical methods that attempt to account for the nonrandom nature of student assignments to classes/teachers, which have been shown to lead to biased estimates of the impact of teacher credentials (Clotfelter, Ladd, and Vigdor, 2007a; Goldhaber, 2007).

The findings show that TFA teachers are more effective, as measured by student exam performance, than traditional teachers. Moreover, they suggest that the TFA effect, at least in the grades and subjects investigated, exceeds the impact of additional years of experience, implying that TFA teachers are more effective than experienced secondary school teachers. The positive TFA results are robust across subject areas, but are particularly strong for math and science classes.

Previous Research

Research examining the impact of TFA teachers on student performance is surprisingly sparse given its rapid expansion and the given the attention that the program has received from the education policy community, college students, and school districts serving low income communities.

We found no research on TFA at the secondary school level. Most work has focused on elementary school teachers and some on middle school teachers. The most prominent study is the random assignment study conducted by Mathematica (Decker, Mayer and Glazerman, 2004). The Mathematica study compares student achievement outcomes among students taught by TFA teachers and other teachers in the same schools and at the same grade levels. The control group tended to be diverse; some teachers were certified and some were not. Because the control group teachers are the set of teachers who would have likely taught the students in the absence of TFA, they are arguably the appropriate comparison group for policy purposes. Students were randomly assigned to teachers prior to the beginning of the school year to ensure there were no systematic differences between the student groups at the outset of the study. Both TFA and traditional teachers in the study were in self-contained classrooms in grade 1 through grade 5. Student outcomes were assessed on the basis of math and reading tests that were administered at the beginning and end of the academic year.

The Mathematica study found that TFA teachers outperformed the control teachers, including experienced teachers, in student math achievement. The impact of

TFA teachers and control teachers was no different in reading achievement. When TFA teachers were compared with novice control teachers, the impact on math achievement was larger than when compared to the full teacher control group, and reading remained insignificant.

Two recent studies estimated TFA effects on student performance using large scale data from New York City. Both focused on reading and math performance of students in grades 4 though 8; both differentiated non-TFA teachers into multiple categories of teachers (e.g., in terms of certification); and both explicitly took experience into account.[3]

Kane, Rockoff, and Staiger (2006) used six years of data and found a small positive effect for TFA on student math achievement (.02 standard deviations) relative to certified teachers, controlling for years of teaching experience. The effect was somewhat smaller for elementary school teachers (.015) and larger for middle school teachers (.027). They also found that the returns to experience were greater for TFA teachers than traditionally certified teachers, though not statistically significant. The experience differentials overall were small such that even a small difference in effectiveness may offset turnover. Similar to the Mathematica study, there were no differences in reading. In general, they found that the certification status of a teacher has at most a small impact on

[3] Two smaller studies of TFA were also conducted with data from Houston (Raymond, Fletcher and Luque, 2001); (Darling-Hammond, Holtzman, Gatlin and Heilig, 2005), but they are not as rigorous as the New York City studies. Both found positive effects for TFA in math on the state test, though the second study found negative effects on other subjects and tests. The first study compared TFA teachers to other teachers in the district; the second study compared TFA teachers holding standard certification.

student performance; and variation in teacher effectiveness within certification categories was large.

Boyd, Grossman, Lankford, Loeb, and Wyckoff (2006) compared the performance of teachers entering teaching in New York City from different pathways, including TFA. They had one year less of data so they work with a smaller sample of TFA teachers than Kane, Rockoff and Staiger (2006). They also distinguish two types of certification status: "college recommended" and individual evaluation. The former refers to teachers who fulfilled certification requirements at a university-based program registered with the state. The latter refers to teachers who fulfilled their requirements at different institutions, including through distance learning.

The Boyd, Grossman, Lankford, Loeb and Wyckoff study compares pathway effects relative to college recommended teachers. They found differences by grade level and subject. In ELA (English/Language Arts), TFA teachers perform somewhat worse than 'college recommended' teachers in their first year teaching, though they tend to catch up to some degree in later years. In middle school math, however, TFA teachers had an advantage right off in their first year teaching. The finding was statistically significant across a number of specifications. Similar to the other New York City study, this study also found that the variation in teacher effectiveness within pathways was greater than the average difference between pathways.[4]

[4] While not directly an examination of TFA, a recent study by Boyd, Lankford, Loeb, Rockoff, and Wyckoff (2007) found a substantial narrowing of the gap in teacher qualifications between schools serving disadvantaged and schools serving more affluent students in New York City between 2000 and 2005. They credit the converging of qualifications to three policy changes: (1) abolishing temporary licenses for

This study focuses on TFA effects in high school, where teacher academic qualifications are particularly important (Goldhaber and Brewer, 2000). Four sections follow. We first describe the data and the variables used in the analysis. The next section discusses the analytic strategy we employ followed by a presentation of results. The final section discusses the implications for policy and practice.

Data

We focus our analysis on North Carolina because of the rich administrative databases available through the North Carolina Education Research Data Center (NCERDC) at Duke University. Since the early 1990s, the state of North Carolina has required schools to administer subject-specific End-of-Course (EOC) exams during the last two weeks of the school year.[5] We estimate the effect of Teach for America teachers relative to traditional-route teachers on student achievement in high school using EOC exam outcomes.

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uncertified teachers; (2) the creation of alternative certification routes; (3) and the creation of the Teacher Fellows Program. The newly hired teachers—TFA and Teaching Fellows—represented 40 percent of all new hires in 2005. On average they have higher test scores and stronger academic backgrounds than other teachers and, by design, are placed disproportionately in high poverty schools where temporarily licensed teachers tended to teach previously. The improved teacher qualifications for the schools serving the most disadvantaged students led to improved student performance between 2000 and 2005. The improvement more than half offset any deficit associated with being a first year teacher. As with other studies, the effects in math were stronger than the effects in ELA. In short, the findings show that recruitment strategies that target teachers with strong academic credentials, like Teach for America, can substantially change outcomes for students.

[5] Subjects tested are Algebra, Algebra II, Geometry, Biology, Chemistry, Physics, Physical Science, English I, US History, Civics and Economics and Occupational Course of Study. We do not include US History, Civics and Economics, or Occupational Course of Study because data for those tests are not available in all years. See Exhibit 1 for a list of courses that require EOC testing.

NCERDC collects data from the North Carolina Department of Public Instruction (NCDPI) at the end of each school year and compiles the data into annual datasets at the student, teacher, classroom,[6] and school levels. Student data contain information on ethnicity, gender, exceptionality status, grade level, district and school code, survey data on parent education and homework habits, and scale score achievement levels for any EOC exams taken by a student in a given year.[7] Teacher data include salary, experience, licensure, educational attainment, PRAXIS test scores, and National Board Certification. Teach for America staff helped us construct a separate dataset showing Teach for America corps members, which NCERDC later linked to their teacher data using social security numbers. Finally, the classroom data contain records for each activity that occurred in a North Carolina public school in a year. Records list course title, section number, semester, subject, grade level, student ethnicity and gender counts, and teacher experience, ethnicity and gender.

We limit our data to the 2000–01 through 2005–06 school years, the years of data available during which Teach for America corps members were teaching in North Carolina. We further limit our sample to the 23 LEAs that hired at least one TFA teacher at any point during this time period. Then we merge each annual student dataset into a

[6] NCERDC calls classroom-level data School Activity Reports.

[7] Some students had multiple records in a year with different EOC scores in each record. All observations for that student in that year were dropped. A very small number of students (less than 0.5 percent) had multiple valid scores on the same subject in one year, mostly a result of school change during the school year. An even smaller number of students (about 0.05 percent) had two identical scores on the same subject in one year with identical teachers associate with the scores. In both of these cases, we dropped those observations. On the other hand, some students took the same EOC subject exam multiple times throughout their high school years; in most cases, they had failed to reach the "proficient" level in earlier attempts. These cases account for five percent of all EOC students. Since repeated testing on the same subject may be a confounding factor in our estimation of teacher effect on student performance, our analysis focuses on first-time test takers only.

student longitudinal file. We apply the same method to the teacher and classroom data, so that we have three longitudinal files, one each at the student, teacher and classroom levels.

To estimate the effect of a teacher on her students' testing outcomes, we must link students to their classroom instructor for the relevant EOC exam. This presents a challenge in North Carolina. The student data identify the proctor of each student's EOC exam, but the proctor is not necessarily the instructor for that student's class. In Goldhaber and Anthony (2004), the authors cite North Carolina state officials who say that at least 90 percent of the time, the students' proctor is the same person as the actual classroom teacher. They verify this information by contacting 20 large school districts and find that the proctor matches the students' classroom teacher 80 percent of the time at the elementary level. At the high school level, in Clotfelter, Ladd, and Vigdor (2007a), the authors link classroom data to the student data using the classroom instructor code and the student exam proctor code and verify those matches using a fit statistic based on classroom demographics. They found a match in about 70 to 75 percent of the cases. Given the success of this method, we apply a matching and verification method similar to that used in Clotfelter, Ladd, and Vigdor (2007a), as described below.

First, individual students on the EOC file were aggregated into test classrooms by district and school code, year, test proctor, subject and class period. Each resulting record is associated with one proctor and lists classroom-level demographic, exceptionality and grade level information. Next, we turn to the actual classroom data. We keep only course descriptors requiring EOC assessments as stipulated by the North Carolina Department of Public Instruction (exhibit 1) and collapse records for the same course meeting that differ only on the semester variable into one record per year.[8] With both the EOC and classroom data aggregated into unique classroom-by-year-by-subject records, they can be matched. To do so, we link all exam classrooms in a school/year with all course activities related to the test subject in that school for that school year. Then we verify the matches using the teacher ID variable and a fit statistic similar to the one used by Clotfelter, Ladd and Vigdor (2007a). This statistic measures the expected squared deviations of total classroom membership count, number of white students, and number of male students between test classrooms and actual instructional classrooms.

We go through a number of steps to verify possible matches. First, we consider those classes matched by uniquely identifiable teacher ID. If more than one exam classroom match occurred for an actual classroom teacher in the same section, course, school and year, we kept the match with the lowest fit statistic (thus closer resemblance between the exam and actual classrooms). Among these retained matches, cases where the fit statistic is greater than or equal to 1.5 are deemed unreliable and hence discarded. The remaining cases are considered “good” matches with reasonable confidence. They constitute our first classroom/teacher sub-sample (sample A).

With those matches set aside, we use the fit statistic to verify classroom matches within school, year and subject that do not match on teacher ID. The general idea is that,

[8] Course activities in the classroom data are unique by district and school code, teacher code, year, subject, course number, and section number. These records are repeated for each semester or quarter of the course.

when an EOC exam is administered by a teacher other than the classroom instructor, if the test classroom sufficiently resembles the instruction classroom in terms of student demographic compositions, a classroom instructor can be reliably assigned to that group of students. The success of this strategy relies on the number of test classrooms within a school-year-subject combination and how distinctive they are. In our high school data set, the median number of test classrooms within each school, year, and subject is 6, and they appear to be sufficiently different from each other to be distinguished by demographic distributions. For each unique actual instructional classroom, we kept the test classroom that matched with the lowest fit statistic. Even after identifying the best match, if the fit statistic was equal to or greater than 1.5, we dropped that classroom. The remaining matches constitute our second classroom/teacher sub-sample (sample B). We then combine those classrooms matched by teacher code and verified with those matched using only the fit statistic. In this dataset, if a test proctor matched two actual classrooms, we kept the match with the lower fit statistic.

Once classroom instructors are identified, we attach them back to the student-level test data and match teacher data to the actual classroom instructor. Using this method, we are able to match about 84 percent of students to their teachers. For the purpose of model estimation, we use two alternative analytical samples to ensure estimated TFA effects are robust to sample selection. The first sample includes all teachers who are either matched on their ID and verified or matched by class demographic variables only. As we are less confident with cases where proctors and instructors are matched solely on the basis of class demographics, the second sample includes only those teachers who are matched on ID and verified by class demographics.

Analytic Strategy

A key challenge to the estimation of TFA teacher effects is possible non-random sorting of teachers and students both across and within schools. Evidence has shown a matching between observed teacher qualifications (such as years of experience) and student achievement, possibly as a result of teacher preference and parent pressure (Clotfelter, Ladd, and Vigdor, 2007a). When teacher quality and student performance are systematically related to student ability and motivation, the relationship between teacher and student performance cannot be reliably estimated. In this particular study, if TFA teachers are assigned to students with greater needs, estimated TFA effects are likely to be downwardly biased; on the other hand, if TFA teachers are systematically assigned to less challenging classes, OLS estimates of TFA effects are likely to be biased upwardly.

To mitigate such potential biases resulting from non-random matching of teachers to students, student fixed-effects models are typically used when longitudinal data are available. These models take advantage of repeated student performance measures over time, and identify teacher effects using within-student variation of teacher inputs:

(1) $y_{it} = \beta_0 + X_{it}\beta + c_i + u_{it}$

y_{it} represents student *i*'s test score in year *t*, and *X* is a vector of individual, family, and teacher characteristics. In this model, the residual term includes two components: a time-constant component c_i, and a "usual" residual component u_{it} that is homoskedastic, uncorrelated with any independent variables or c_i, and not autocorrelated. c_i captures any student characteristics that are fixed over time, both observed (such as gender and race/ethnicity) and unobserved characteristics (such as ability and academic orientation) that may be related to teacher sorting. Since these characteristics are constant for each student over time, they drop out of the equation by demeaning equation 1. In this way, the confounding factors of non-random teacher-student sorting are removed, and teacher effects can be consistently estimated.

In our high school analysis, however, we do not have repeated measures of student performance in a particular subject over time. Most often, students take a subject, such as Algebra I, once. As a result, this study adopts an ingenious fixed-effects model used by Clotfelter, Ladd, and Vigdor (2007a) given the rich nature of the North Carolina data. Instead of using within-student variation *over time*, the model takes advantage of within-student variation *across subjects* that are evaluated by end-of-course exams in North Carolina.[9]

(2) $y_{ij} = \beta_0 + T_{ij}\beta + c_i + u_{ij}$

The subscript *j* denotes EOC subjects. T_{ij} represents student *i*'s teacher in subject *j*. The key variable of interest in this vector is a TFA indicator variable that equals to 1 if the teacher is affiliated with the TFA program and 0 otherwise. T_{ij} can also include other teacher qualification variables such as teacher experience as well as classroom variables. Analogous to a standard student fixed-effects model, c_i captures student characteristics

[9] Dee and Cohodes (2008) use a similar strategy with the National Education Longitudinal Study of 1988 (NELS: 88).

such as unobserved ability that are constant across test subjects. Although it may be reasonable to assume general student ability to be relatively stable over time, whether or not student ability captured by this error term is constant across subjects needs to be verified. If $c_{ij} = c_i$ for all *j*, the fixed-effects transformed equation of this cross-subject model is:

$$(3)\ y_{ij} - \overline{y_i} = (T_{ij} - \overline{T_i})\beta + u_{ij} - \overline{u_i}$$

where variables with a superscript bar denote student-specific means across subjects and c_i is removed from the equation.

As should be clear, whether or not the student-specific error term varies by subject is key to the validity of cross-subject fixed-effects models. If the assignment of TFA teachers is based on subject-specific student ability that is multi-dimensional, the non-random matching of teachers to students remains unaccounted for in these fixed-effects models.

Using the same North Carolina high school data, Coltfelter, Ladd and Vigdor (2007a) investigate this crucial question in great detail. Their investigation concludes that in North Carolina high schools, student ability varies little by subject (with slightly larger difference between English and other math and science-related subjects); when schools assign students to classrooms, they appear to consider student ability to be “single dimensional”. For further assurance, we conducted a direct examination of the eight core EOC subjects using principal component analysis. The results show that all tests are loaded predominantly on one single underlying dimension, lending further support to the assumption that students performing well in one subject are also likely to perform well in other subjects, and that any teacher-student sorting based on the ability in one subject probably will follow similar patterns if such sorting were based on student ability in any other subjects. (See figure 1.)

The lack of an initial student performance measure in a specific subject has another important implication for our cross-subject student fixed-effects model. Since education is a cumulative process, academic performance depends not only on contemporaneous inputs but also on inputs from all previous time periods. Levels of academic performance at the beginning of the current time period capture students' cumulative education experiences up until that point. As a result, value-added models are typically used to estimate teacher effects on student performance. Without initial test scores for high school EOC subjects, we are not able to specify a model that controls for lagged student performance on the right hand side of the equation (or the construction of a gain score).

In effect, our model without pre-test information assumes complete "decay" of prior input; that is, initial academic preparation in a specific subject at the time of class enrollment has negligible effect on EOC test scores. What the cross-subject model does account for is the overall level of performance across eight subjects. Clotfelter, Ladd, and Vigdor (2007b) argue that a model with a missing lagged term leads to downward bias in estimates, and that the less the decay, the larger the downward bias.[10] The TFA effect

[10] The authors acknowledge the insights from Rivkin (2006) and Hanushek, Kain and Rivkin (2006) as the basis of this observation.

estimated using the cross-subject model, therefore, is likely to provide the lower bound of the true effects.

Variables and Model Specification

The North Carolina Department of Public Instruction requires students taking certain high school courses for credit to take End-of-Course (EOC) tests on multiple subjects, including eight core subjects requiring testing for the entire span of years in our dataset (Algebra I, Algebra II, Geometry, Physical Sciences, Physics, Chemistry, Biology, and English I). Our dependent variable is standardized EOC test scores in these eight subjects. The scores are standardized by subject and year, with mean 0 and standard deviation 1. By this transformation, scores from different tests are put on the same scale. It is important to note, however, that these standardized test scores represent each student's performance relative to all other test-takers in the same year and subject across the 23 LEAs under study.

Our key independent variable is a TFA indicator variable. Control variables include teacher experience, gender, race/ethnicity, and education attainment. We also include class size and peer average achievement to control for classroom environment. All models are estimated with subject by grade fixed-effects as well as year fixed-effects. Even though the analysis is based on 23 LEAs that hired TFA teachers, significant heterogeneity may still remain in terms of school characteristics and overall school environment. As a result, models are also estimated by including school fixed-effects.

This study focuses on the overall effectiveness of TFA teachers as compared to non-TFA teachers. Such relative effectiveness may be the result of a couple of factors, such as differences in academic preparation in a subject area and in pedagogical training. However, because the key research question of this study is whether or not the TFA program can provide effective teachers to supplement the existing teaching force, our model does not include variables such as the selectivity of higher education institutions attended by teachers or license test scores. Descriptive comparisons do show, however, that disparities do exist between TFA and non-TFA teachers in terms of their academic preparation.

Results

Tables 1–3 present comparisons of TFA teachers with all non-TFA teachers as well as novice non-TFA teachers in the 23 LEAs under study. Novice teachers are defined as teachers with less than three years of experience.

Compared with non-TFA teachers and novice non-TFA teachers, a smaller percent of TFA teachers are from race/ethnic minority groups (table 1). About 18 percent of TFA teachers are non-White, compared with about 23 percent and 27 percent minorities among all non-TFA teachers and novice non-TFA teachers respectively. TFA teachers are typically new college graduates. As a result less than 2 percent of them have a Master’s degree or higher. By contrast, 34 percent of all non-TFA teachers and 19 percent of novice non-TFA teachers have a graduate degree. However, significantly more TFA teachers have graduated from “most selective” or “very selective” higher education institutions than non-TFA teachers do (64 percent versus 23 percent). TFA teachers also have higher PRAXIS scores on average than non-TFA teachers (about 0.4 standard deviations higher). Finally, higher percentages of TFA teachers are licensed in the subject area they teach than non-TFA teachers (90 percent versus 82 percent in science subjects, 73 percent versus 69 percent in math subjects, and 89 percent versus 67 percent in English).

TFA and non-TFA teachers are also assigned to classrooms and students with distinct characteristics and performance levels. Classes taught by TFA teachers on average have much higher minority concentrations (about 80 percent) as compared to those taught by non-TFA teachers (49 percent for all non-TFA teachers and 54 percent for novice non-TFA teachers). (See table 2.) However, TFA classrooms have lower percentages of LEP students than non-TFA classrooms. In general, TFA teachers are assigned to more academically challenged classrooms. Using achievement levels defined by the North Carolina Department of Public Instruction, table 2 shows that lower percentages of students in classrooms taught by TFA teachers have achieved a “superior performance” or “consistent mastery” rating in all subject areas. The contrast is more striking if we look at the “superior performance” level only. Classes of non-TFA teachers have at least twice as many students performing at this highest level in terms of percentage than classes of TFA teachers (except for Physical Science). Classes of novice non-TFA teachers perform at somewhat lower levels compared to those taught by more experience non-TFA teachers, but they are still performing at significantly higher levels than classes of TFA teachers.

Similar patterns emerge when we compare TFA and non-TFA teachers at the student level. Students of TFA teachers are more likely to be race/ethnic minorities, less likely to be LEP students, less likely to have parents with Bachelor's degrees or higher, and have lower standardized scale scores on EOC assessments across all subjects. Students of novice non-TFA teachers have lower average scores than those taught by more experienced non-TFA teachers, but they still have clear advantage over students of TFA teachers.

In short, TFA teachers differ significantly from non-TFA teachers (both novice and overall) in terms of their demographic characteristics, academic preparation, experience, as well as the classes and students they teach. Such patterns are consistent with findings from earlier studies on TFA teachers using data from different states. The TFA program selects graduates from the most competitive undergraduate institutions and places them as teachers in the lowest-performing schools in the country. And TFA teachers are placed in the most demanding classrooms in these already challenging schools.

Such non-random assignment of TFA teachers to classrooms and students needs to be accounted for before reliable TFA effects can be estimated. Using the analytic strategy discussed in the previous section, student fixed-effects models are estimated. Results are presented in tables 4-A and 5-A. Each table shows two models, one without classroom variables and the other with controls for those variables. Table 4-A uses all eight EOC subjects. Because humanities may follow a somewhat different path than the development of math and science skills, table 5-A excludes English I scores and estimates models for high school math and science subjects only.[11]

The effect of having a TFA teacher as compared to having a non-TFA teacher on high school student performance is stable and consistent across models and specifications. In models where classroom characteristics are not controlled for, having a TFA teacher is associated with about 0.12 standard deviations improvement in EOC performance (0.13 standard deviations if we exclude English I) as compared with having a non-TFA teacher. This effect is about twice the effect of having a teacher with 3 years or more experience relative to having a novice teacher. Evidence shows that, in terms of test scores, TFA teachers are able to more than offset their lack of teaching experience, either due to their better academic preparation in particular subject areas or due to other unmeasured factors such as motivation. Consistent with the literature, our estimates show that the first three years of teaching experience makes a significant difference in teacher effectiveness, but the experience effect diminishes after that point. Excluding English I test scores from the dependent variable results in marginally stronger TFA effects.

Adding classroom variables reduces TFA effects to about 0.07 standard deviations, but it remains statistically significant. As a comparison, the effect of teacher experience is reduced even more. In these models, the TFA effect is just below three

[11] We are able to estimate TFA effects for math and science teachers because scores from multiple EOC tests in each subject area are available (Algebra I, Algebra II, and Geometry for math, and Physical Science, Biology, Chemistry, and Physics for science). By comparison, we are not able to estimate TFA effects for English teachers only, as we only have English I test scores and hence there is no cross-subject variation that we can exploit to estimate cross-subject fixed-effects models.

times the effect of having a teacher with three to five years of experience relative to having a novice teacher. Additionally, teachers with six or more years of experience have less advantage over novice teachers than teachers with three to five years of experience. One possible explanation is that it may be easier for more experienced teachers to choose high-performing classes to teach, as shown in descriptive table 2. As a result, after class size and average student performance are controlled, the estimated effect of these teachers is reduced more than that of their colleagues.[12]

In order to check the robustness of our estimated TFA effects, this study re-estimates these effects by using various model specifications and analytical samples. First, a significant amount of heterogeneity may exist across schools as a result of factors such as differences in school leadership and management. To account for such heterogeneity, we re-estimate the models presented in tables 4-A and 5-A by including school fixed-effects to remove cross-school variation in unobserved school characteristics. The new estimates are presented in tables 4-B and 5-B. All the coefficients change only marginally after the inclusion of school fixed-effects. With classroom variables included, students of TFA teachers on average have a 0.06 standard deviations (0.07 standard deviations with English I scores excluded) advantage in EOC test scores over their peers.

Next, because we do not have additional information to verify the validity of those student-teacher matches where test proctor IDs and instructor IDs do not match and

[12] We also estimate models in which TFA teachers are compared with novice non-TFA teachers only. In those models, we find even stronger TFA effects: 0.071 when we include all 8 subjects, and 0.082 when we look at math and science teachers only.

the student-teacher link is established solely on the basis of classroom demographic distributions, we are not able to evaluate the scope of possible mismatches between students and teachers in those cases and its impact on model estimates. Therefore, we re-estimate our models by excluding those cases. These results are presented in table 6. Using only those students whose classroom teachers and test proctors have the same uniquely identifiable IDs, and whose instructional classrooms sufficiently resemble the test classrooms in terms of demographic characteristics, we find slightly stronger TFA effects (both with and without English I scores) that are statistically significant. Similar to the results obtained when using larger samples, TFA effects remain about three times the effect of having three to five years of teaching experience.

Finally, as shown in descriptive table 1, a disproportionately higher percentage of non-TFA teachers teach a subject outside of their license field than TFA teachers. We are interested in whether TFA teachers are as effective as those non-TFA teachers who are licensed in the subjects they teach. Table 7 compares all TFA teachers with non-TFA teachers certified in the subjects they teach, and table 8 compares TFA and non-TFA teachers, both teaching within their certified subject areas. In both cases, TFA teachers retain an advantage of 0.7 standard deviations over non-TFA teachers in student performance on EOC assessments. When these same models are run using school fixed effects, the results are the same, if not stronger, as shown in tables 9a, 9b and 9c.

Discussion

The research reported here is related to larger education policy and practice concerns about teacher quality, especially teacher quality for disadvantaged students. Teach for America taps into a non-traditional pool for teachers. The teachers TFA recruits and selects differ from traditional teachers, on average, in a number of ways. They tend to have stronger academic credentials; they have not been prepared in traditional teacher training programs; they are more likely to teach for only a few years; and they are assigned to the most challenging schools in the country. Given these differences, the program has been controversial. Research providing guidance on the merits of the program to policy makers and to local education administrators has been scant at the elementary school level and non-existent at the secondary school level. This study represents the first study at the secondary school level.

Our findings show that secondary school TFA teachers are more effective than the teachers who would otherwise be in the classroom in their stead. While these other teachers are a diverse group in terms of background and training, for policy purposes they are an appropriate comparison group. Other things being equal, the findings suggest that disadvantaged students taught by TFA teachers are better off than they would be in the absence of TFA.

But there are additional policy questions. Suppose we raised the bar on teacher qualifications and require that all secondary school teachers be fully licensed in their field, particularly teachers of math and science. Raising the bar may also means we would have to raise salaries to attract sufficient numbers of qualified teachers. But under these conditions, would students be better or worse off with a TFA teacher? To examine this question we restricted the comparison to traditional teachers who were fully certified in field. The TFA advantage still held.

Or suppose we required that all teachers teaching disadvantaged secondary school students have, say, three years of prior experience. Would students be better or worse off with TFA teachers on average? The findings show that TFA status more than offsets any experience effects. Disadvantaged secondary students would be better off with TFA teachers, especially in math and science, than with fully licensed in-field teachers with three or more years of experience.

We should note that the findings here do not necessarily mean that there is no value to teacher training. It is possible that the teachers that TFA recruits and selects would be even more effective with more pedagogical training.

The findings have important implications for the recruitment and selection aspects of human resource management in education, at least for secondary school teachers. They stress the likely importance of strong academic backgrounds for secondary school teachers. They also suggest that policy makers should focus more on issues of teacher selection, and less on issues of teacher retention, if the concern is the performance of disadvantaged secondary school students especially in math and science. In short, they suggest that programs like TFA that focus on recruiting and selecting academically talented recent college graduates and placing them in schools serving disadvantaged students can help reduce the achievement gap, even if teachers stay in teaching only a few years.

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Appendix

Exhibit 1. Courses for credit that require End-of-Course assessments, by subject

Name of course	End-of-course exam required
English I	English I
Algebra I B Algebra I Integrated Math II	Algebra I
Geometry Integrated Math III	Geometry
Algebra II Integrated Math III	Algebra II
Biology Biology II	Biology
Chemistry Chemistry II	Chemistry
Physical Science	Physical Science
Physics Physics II IB Physics III	Physics

Source: North Carolina Department of Public Instruction.
http://www.ncpublicschools.org/docs/accountability/reporting/eoccreditcourses.pdf
Retrieved on March 3, 2008

Figure 1. Screenplot of Eigen-values after principal component analysis of eight EOC assessment subjects

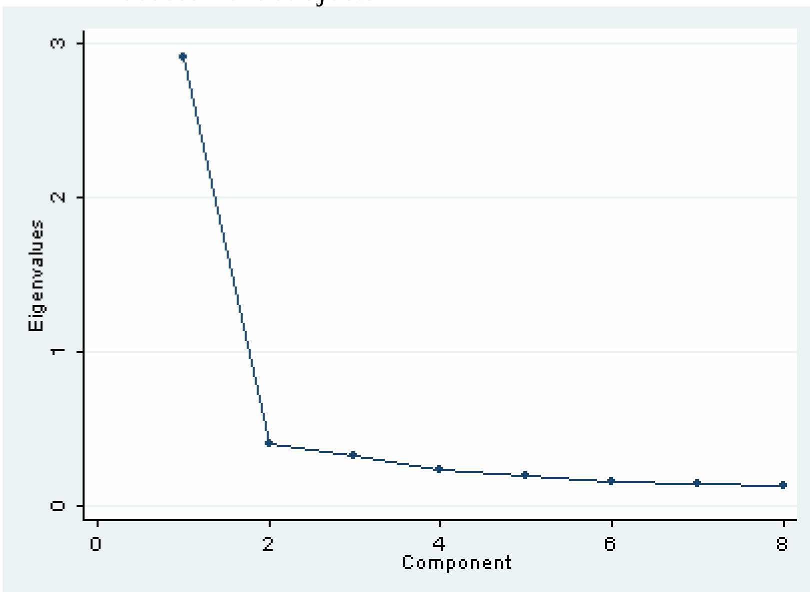

Table 1. Characteristics of TFA and traditional high school teachers in North Carolina school districts that accepted TFA teachers: Year 2000-01 through 2005-06

	TFA teacher		Traditional teacher			Novice Trad. teacher[1]		
	Mean	Std Err	Mean		Std Err	Mean		Std Err
Sex (percent)								
Female	73.59	4.30	69.74		0.39	69.09		0.86
Male	26.42	4.30	30.26		0.39	30.91		0.86
Race (percent)								
Black	5.66	2.26	20.81	*	0.34	23.20	*	0.79
Hispanic	1.89	1.33	0.57		0.06	1.14		0.20
White	82.08	3.74	77.10		0.35	73.55	*	0.82
Other	10.38	2.98	1.52	*	0.10	2.11	*	0.27
Overall teaching experience	0.57	0.07	11.78	*	0.09	0.86	*	0.02
Education attainment (percent)								
Bachelor's	98.11	1.33	65.90	*	0.40	81.09	*	0.73
Master's	1.89	1.33	32.11	*	0.40	18.57	*	0.72
Advanced/Doctorate	0.00	0.00	1.98	*	0.12	0.35	*	0.11
Selectivity of IHE[2]								
Most selective	19.81	3.89	2.28	*	0.13	2.94	*	0.31
Very selective	44.34	4.85	20.85	*	0.34	24.45	*	0.80
Moderately selective	35.85	4.68	57.74	*	0.41	54.25	*	0.93
Not selective/not ranked	0.00	0.00	19.13	*	0.33	18.36	*	0.72
License test score (PRAXIS)[3]	0.37	0.08	-0.03	*	0.01	-0.01	*	0.02
Licensed in subject taught[4,5]								
Science	90.63	3.67	81.80	*	0.52	80.35	*	1.20
Math	73.33	8.21	68.93		0.49	69.02		1.15
English	89.47	5.05	66.73	*	0.82	71.65	*	1.60
Number of unique teachers	69		5,678			1,959		
Number of teacher/year obs	106		14,262			2,892		

* Significantly different from TFA teachers at .05 level.

[1] Novice teachers are those with fewer than 3 years experience

[2] Based on Petersons College Selectivity Rankings

[3] There were 61 TFA teacher/year observations and 12,241 traditional teacher/year observations (2,214 novice) with valid PRAXIS scores. Scores are standardized onto the same scale across years.

[4] Science Licenses include: BIOLOGY (GRADES 9-12), CHEMISTRY (GRADES 9-12), EARTH SCIENCE (GRADES 9-12), PHYSICAL SCIENCE (GRADES 9-12), PHYSICS (GRADES 9-12), and SCIENCE (GRADES 9-12). Math licenses include MATHEMATICS (GRADES 9-12). English licenses include ENGLISH (GRADES 9-12) and READING (GRADES K-12).

[5] Science classes are Biology, Chemistry, Physical Science, and Physics. Math classes are Algebra I, Algebra II, and Geometry. English includes only English I.

Note: Population is limited to teachers who were positively matched to their students

Source: North Carolina Education Research Data Center

Table 2. Characteristics of classes taught by TFA and traditional high school teachers in North Carolina school districts that accepted TFA teachers: Year 2001-06

	TFA teacher		Traditional teacher			Novice Trad. teacher[1]		
	Mean	Std Err	Mean		Std Err	Mean		Std Err
Average class size	20.45	0.63	19.88		0.05	19.30		0.10
Percent minority	80.10	1.16	49.36	*	0.14	54.24	*	0.32
Percent handicapped/learning disability	10.08	1.32	10.99		0.11	13.64	*	0.29
Percent LEP	2.12	0.43	3.27	*	0.05	3.32	*	0.11
Percent Male	47.50	0.94	50.76	*	0.09	51.94	*	0.19
Percent achieving at level[2]								
Algebra I								
Superior performance	14.73	3.80	31.02	*	0.32	25.83	*	0.63
Consistent mastery	53.67	4.17	38.12	*	0.24	39.24	*	0.52
Inconsistent mastery	27.92	4.30	25.24		0.26	28.50		0.59
Insufficient mastery	3.68	1.17	5.62		0.14	6.43	*	0.33
Algebra II								
Superior performance	15.04	2.69	35.15	*	0.43	28.58	*	1.11
Consistent mastery	44.82	3.06	36.05	*	0.30	35.72	*	0.70
Inconsistent mastery	37.90	3.62	25.90	*	0.36	31.70		0.96
Insufficient mastery	2.24	0.72	2.90		0.12	4.00	*	0.36
Biology								
Superior performance	6.48	1.48	17.25	*	0.25	12.85	*	0.48
Consistent mastery	34.78	2.50	40.11	*	0.25	37.34		0.54
Inconsistent mastery	41.49	2.37	27.54	*	0.25	30.33	*	0.53
Insufficient mastery	17.25	2.16	15.10		0.26	19.48		0.64
Chemistry								
Superior performance	14.83	2.29	31.28	*	0.45	21.62	*	0.93
Consistent mastery	36.68	2.63	36.28		0.30	35.59		0.71
Inconsistent mastery	36.87	2.98	22.49	*	0.31	28.55	*	0.75
Insufficient mastery	11.62	1.71	9.96		0.26	14.24		0.68
Geometry								
Superior performance	6.50	1.83	23.91	*	0.36	19.83	*	0.83
Consistent mastery	28.85	3.73	36.06		0.28	36.61	*	0.65
Inconsistent mastery	49.31	4.04	32.78	*	0.34	34.99	*	0.80
Insufficient mastery	15.34	3.83	7.25	*	0.19	8.57		0.50
Physics								
Superior performance	16.05	3.81	40.63	*	0.79	36.13	*	2.26
Consistent mastery	51.18	5.05	39.44	*	0.56	42.96		1.59
Inconsistent mastery	24.35	5.34	14.99		0.45	15.69		1.26
Insufficient mastery	8.42	2.45	4.94		0.30	5.22		0.69
Physical science								
Superior performance	7.18	2.63	11.20		0.30	9.85		0.64
Consistent mastery	50.85	3.94	44.40		0.44	41.51	*	0.97
Inconsistent mastery	39.57	5.20	35.30		0.46	37.05		0.97
Insufficient mastery	2.40	1.19	9.10	*	0.33	11.59	*	0.84
English I								
Superior performance	12.51	1.50	30.51	*	0.32	27.12	*	0.65
Consistent mastery	49.72	2.24	37.68	*	0.25	38.24	*	0.53
Inconsistent mastery	28.35	1.80	22.30	*	0.25	24.36	*	0.53
Insufficient mastery	9.43	1.49	9.52		0.21	10.29		0.44
Number of classes	331		50,048			9,182		

* Significantly different from TFA teachers at .05 level.

[1] Novice teachers are those with fewer than 3 years experience
[2] These are achievement levels defined by North Carolina Department of Public Instruction
Note: Population is limited to teachers who were positively matched to their students
Source: North Carolina Education Research Data Center

Table 3. Characteristics of students taught by TFA and traditional high school teachers in North Carolina school districts that accepted TFA teachers: Year 2001-06

	TFA teacher		Traditional teacher			Novice Trad. teacher[1]		
	Mean	Std Err	Mean		Std Err	Mean		Std Err
Sex (percent)								
Female	53.60	0.66	50.17	*	0.10	50.55	*	0.14
Male	46.41	0.66	49.83	*	0.10	49.45	*	0.14
Race (percent)								
Black	71.38	0.60	35.71	*	0.09	37.50	*	0.14
Hispanic	2.94	0.22	5.42	*	0.04	5.36	*	0.06
White	21.95	0.55	53.08	*	0.09	51.38	*	0.14
Other	3.73	0.25	5.80	*	0.04	5.76	*	0.07
Exceptionality (percent)								
Gifted	7.28	0.34	13.20	*	0.06	10.28	*	0.09
Learning disability	4.43	0.27	4.55		0.04	4.59		0.06
Handicapped	2.71	0.21	3.22	*	0.03	3.08		0.05
Non-exceptional	85.59	0.46	75.05	*	0.08	76.98	*	0.12
LEP students (percent)	1.82	0.18	2.89	*	0.03	2.75	*	0.05
Parents' education attainment								
Less than high school	9.57	0.39	5.78	*	0.04	5.54	*	0.06
High school diploma	33.64	0.63	19.76	*	0.08	19.38	*	0.11
Some college	34.60	0.63	28.04	*	0.09	28.70	*	0.13
Bachelor's	16.63	0.49	29.62	*	0.09	29.77	*	0.13
Graduate degree	5.49	0.30	15.71	*	0.07	15.75	*	0.10
Achievement scores[2]								
Algebra I	-0.39	0.03	0.00	*	0.00	-0.16	*	0.01
Algebra II	-0.55	0.03	0.00	*	0.00	-0.21	*	0.01
Biology	-0.48	0.02	0.00	*	0.00	-0.18	*	0.01
Chemistry	-0.41	0.03	0.00	*	0.00	-0.25	*	0.01
Geometry	-0.57	0.03	0.00	*	0.00	-0.14	*	0.01
Physics	-0.58	0.05	0.01	*	0.01	-0.12	*	0.02
Physical science	-0.18	0.06	0.00	*	0.00	-0.13		0.01
English I	-0.63	0.02	0.01	*	0.00	-0.10	*	0.01
Number of unique students	5,758		279,884			127,492		

* Significantly different from TFA teachers at .05 level.

[1] Novice teachers are those with fewer than 3 years experience

[2] Standardized scores by subject and year

[3] The total number of unique students in our sample is smaller than the sum of these numbers, as students may be taught by both TFA and traditional teachers

Note: Population is limited to teachers who were positively matched to their students and unique students

Source: North Carolina Education Research Data Center

Table 4-A. Student fixed-effects estimates, high school: Eight subjects including English I

Independent variables	Without classroom variables Coef.	Std. Err.		With classroom variables Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.109**	**0.008**	*	**0.065**	**0.008**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.052	0.002	*	0.022	0.002	*
6 to 10 years	0.053	0.002	*	0.013	0.002	*
11 years or more	0.048	0.002	*	0.006	0.002	*
Male (ref: female)	-0.062	0.001	*	-0.024	0.001	*
Race (ref: other minorities)						
Black	-0.020	0.005	*	0.004	0.005	
White	0.027	0.005	*	0.006	0.005	
Hispanic	-0.026	0.010	*	-0.010	0.009	
Education attainment (ref: BA)						
Master's degree	-0.002	0.001		-0.005	0.001	*
Advanced/Doctoral degree	-0.020	0.005	*	-0.019	0.004	*
Classroom characteristics						
Peer average achievement				0.450	0.001	*
Class size				-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics, Physical science and English I

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 4-B. Student fixed-effects estimates, high school: Eight subjects including English I with school fixed-effects

Independent variables	Without classroom variables Coef.	Without classroom variables Std. Err.		With classroom variables Coef.	With classroom variables Std. Err.	
TFA teacher (ref: traditional teachers	**0.117**	**0.008**	*	**0.064**	**0.008**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.052	0.002	*	0.024	0.002	*
6 to 10 years	0.053	0.002	*	0.015	0.002	*
11 years or more	0.046	0.002	*	0.007	0.002	*
Male (ref: female)	-0.059	0.001	*	-0.023	0.001	*
Race (ref: other minorities)						
Black	-0.025	0.005	*	-0.001	0.005	
White	0.014	0.005	*	0.002	0.005	
Hispanic	-0.052	0.010	*	-0.021	0.009	*
Education attainment (ref: BA)						
Master's degree	-0.004	0.001	*	-0.006	0.001	*
Advanced/Doctoral degree	-0.017	0.005	*	-0.018	0.004	*
Classroom characteristics						
Peer average achievement				0.448	0.001	*
Class size				-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics, Physical science and English I

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 5-A. Student fixed-effects estimates, high school: Seven math and science subjects

Independent variables	Without classroom variables			With classroom variables		
	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.123**	**0.010**	*	**0.073**	**0.009**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.056	0.003	*	0.025	0.002	*
6 to 10 years	0.057	0.002	*	0.015	0.002	*
11 years or more	0.049	0.002	*	0.004	0.002	*
Male (ref: female)	-0.060	0.002	*	-0.021	0.001	*
Race (ref: other minorities)						
Black	-0.033	0.006	*	-0.008	0.005	
White	0.014	0.005	*	-0.004	0.005	
Hispanic	-0.022	0.010	*	-0.016	0.010	
Education attainment (ref: BA)						
Master's degree	0.000	0.002		-0.001	0.002	
Advanced/Doctoral degree	-0.008	0.005		-0.010	0.005	*
Classroom characteristics						
Peer average achievement				0.440	0.002	*
Class size				-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics and Physical science

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 5-B. Student fixed-effects estimates, high school: Seven math and science subjects with school fixed-effects

	Without classroom variables			With classroom variables		
Independent variables	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.130**	**0.010**	*	**0.070**	**0.009**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.055	0.003	*	0.026	0.002	*
6 to 10 years	0.056	0.002	*	0.018	0.002	*
11 years or more	0.047	0.002	*	0.006	0.002	*
Male (ref: female)	-0.057	0.002	*	-0.020	0.002	*
Race (ref: other minorities)						
Black	-0.041	0.006	*	-0.014	0.005	*
White	0.000	0.005		-0.009	0.005	
Hispanic	-0.048	0.010	*	-0.024	0.010	*
Education attainment (ref: BA)						
Master’s degree	-0.002	0.002		-0.003	0.002	*
Advanced/Doctoral degree	-0.008	0.005		-0.010	0.005	*
Classroom characteristics						
Peer average achievement				0.435	0.002	*
Class size				-0.001	0.000	*

* Significant at level .05
Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics and Physical science

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 6. Student fixed-effects estimates, high school: ID-matched[1] teachers only

	Eight subjects including Eng I			Seven subjects excluding Eng I		
Independent variables	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.089**	**0.011**	*	**0.096**	**0.013**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.027	0.003	*	0.034	0.004	*
6 to 10 years	0.013	0.003	*	0.015	0.003	*
11 years or more	0.003	0.003		0.001	0.003	
Male (ref: female)	-0.031	0.002	*	-0.029	0.002	*
Race (ref: other minorities)						
Black	-0.001	0.007		-0.018	0.008	*
White	0.010	0.007		-0.006	0.007	
Hispanic	-0.042	0.014	*	-0.056	0.015	*
Education attainment (ref: BA)						
Master’s degree	-0.005	0.002	*	0.001	0.002	
Advanced/Doctoral degree	-0.029	0.006	*	-0.018	0.006	*
Classroom characteristics						
Peer average achievement	0.434	0.002	*	0.423	0.002	*
Class size	0.000	0.000		0.000	0.000	*

* Significant at level .05

[1] The sample used in the table includes cases in which test proctor ID and classroom instructor ID are identical and classroom demographic characteristics are matched (i.e. “Sample A” as described on p. 10).

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics, Physical science and English I

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 7. Student fixed-effects estimates, high school: All TFA vs. in-field traditional teachers

	Eight subjects including Eng I			Seven subjects excluding Eng I		
Independent variables	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.069**	**0.008**	*	**0.073**	**0.010**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.024	0.002	*	0.027	0.003	*
6 to 10 years	0.017	0.002	*	0.020	0.002	*
11 years or more	0.006	0.002	*	0.005	0.002	*
Male (ref: female)	-0.025	0.001	*	-0.022	0.002	*
Race (ref: other minorities)						
Black	-0.005	0.005		-0.016	0.006	*
White	-0.002	0.005		-0.010	0.005	
Hispanic	-0.019	0.010		-0.022	0.011	*
Education attainment (ref: BA)						
Master's degree	-0.007	0.001	*	-0.006	0.002	*
Advanced/Doctoral degree	-0.020	0.005	*	-0.010	0.005	*
Classroom characteristics						
Peer average achievement	0.447	0.002	*	0.438	0.002	*
Class size	-0.001	0.000	*	-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics, Physical science and English I

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 8. Student fixed-effects estimates, high school: In-field TFA vs. in-field traditional teachers

	Eight subjects including Eng I			Seven subjects excluding Eng I		
Independent variables	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.068**	**0.008**	*	**0.072**	**0.010**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.024	0.002	*	0.027	0.003	*
6 to 10 years	0.016	0.002	*	0.019	0.002	*
11 years or more	0.006	0.002	*	0.005	0.002	*
Male (ref: female)	-0.025	0.001	*	-0.022	0.002	*
Race (ref: other minorities)						
Black	-0.004	0.005		-0.015	0.006	*
White	-0.001	0.005		-0.009	0.005	
Hispanic	-0.020	0.010		-0.022	0.011	*
Education attainment (ref: BA)						
Master's degree	-0.007	0.001	*	-0.006	0.002	*
Advanced/Doctoral degree	-0.020	0.005	*	-0.010	0.005	*
Classroom characteristics						
Peer average achievement	0.447	0.002	*	0.438	0.002	*
Class size	-0.001	0.000	*	-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics, Physical science and English I

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 9a. Student fixed-effects estimates, high school: In-field TFA vs. in-field traditional teachers in all eight EOC subjects, with school fixed effects

	Without Classroom variables			With Classroom variables		
Independent variables	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.128**	**0.009**	*****	**0.070**	**0.008**	*****
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.052	0.002	*	0.024	0.002	*
6 to 10 years	0.056	0.002	*	0.016	0.002	*
11 years or more	0.046	0.002	*	0.006	0.002	*
Male (ref: female)	-0.062	0.002	*	-0.024	0.001	*
Race (ref: other minorities)						
Black	-0.027	0.006	*	-0.003	0.005	
White	0.009	0.005		0.001	0.005	
Hispanic	-0.037	0.011	*	-0.019	0.010	
Education attainment (ref: BA)						
Master’s degree	-0.003	0.002		-0.006	0.001	*
Advanced/Doctoral degree	-0.018	0.005	*	-0.019	0.005	*
Classroom characteristics						
Peer average achievement				0.446	0.002	*
Class size				-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics, Physical science and English I

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 9b. Student fixed-effects estimates, high school: In-field TFA vs. in-field traditional teachers in math and science, with school fixed effects

Independent variables	Without Classroom variables Coef.	Std. Err.		With Classroom variables Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.144**	**0.011**	*	**0.077**	**0.010**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.056	0.003	*	0.026	0.003	*
6 to 10 years	0.059	0.003	*	0.018	0.002	*
11 years or more	0.047	0.002	*	0.004	0.002	*
Male (ref: female)	-0.061	0.002	*	-0.021	0.002	*
Race (ref: other minorities)						
Black	-0.042	0.006	*	-0.014	0.006	*
White	-0.002	0.006		-0.007	0.005	
Hispanic	-0.033	0.012	*	-0.020	0.011	
Education attainment (ref: BA)						
Master's degree	-0.004	0.002	*	-0.005	0.002	*
Advanced/Doctoral degree	-0.008	0.005		-0.010	0.005	
Classroom characteristics						
Peer average achievement				0.435	0.002	*
Class size				-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, Biology, Chemistry, Geometry, Physics and Physical science

All models include subject by grade fixed-effects as well as year fixed-effects.

Table 9c. Student fixed-effects estimates, high school: In-field TFA vs. in-field traditional teachers in math only, with school fixed effects

	Without Classroom variables			With Classroom variables		
Independent variables	Coef.	Std. Err.		Coef.	Std. Err.	
TFA teacher (ref: traditional teachers	**0.159**	**0.025**	*	**0.113**	**0.024**	*
Other Teacher characteristics						
Teacher experience (ref: <3 yrs)						
3 to 5 years	0.049	0.005	*	0.030	0.004	*
6 to 10 years	0.055	0.004	*	0.027	0.004	*
11 years or more	0.043	0.004	*	0.012	0.004	*
Male (ref: female)	-0.062	0.003	*	-0.031	0.003	*
Race (ref: other minorities)						
Black	0.015	0.010		0.022	0.009	*
White	0.028	0.010	*	0.016	0.009	
Hispanic	-0.007	0.025		0.003	0.024	
Education attainment (ref: BA)						
Master's degree	0.018	0.003	*	0.010	0.003	*
Advanced/Doctoral degree	0.009	0.015		0.007	0.014	
Classroom characteristics						
Peer average achievement				0.369	0.003	*
Class size				-0.001	0.000	*

* Significant at level .05

Note: Included EOC subjects are: Algebra I, Algebra II, and Geometry

All models include subject by grade fixed-effects as well as year fixed-effects.

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