Table 1. Pearson Correlation Coefficients of the Correlations of School Average Test Score Gains in Mathematics and Reading Across Grades and Year s

		Mathematics Grade of Cohort II				Reading Grade of Cohort II		
		5	6	7		5	6	7
Grade of Cohort I	5	0.32**				0.19**		
	6	0.13**	0.52**			0.14**	0.43**	
	7		0.05	0.48**			-0.01	0.46**

Notes: Cohort I attended 5th grade in 1994; Cohort II attended 5th grade in 1995. Thus, for example, Cohort I is attending the 6th grade during the same academic year that Cohort II is attending the 5th grade. All calculations are weighted by the average enrollment of the pairs.

*: Significant at 10% level; ** significant at 1% level

Table 2. Comparison of the Explanatory Power of Teacher Experience, Education, and Class Size with Teacher Fixed Effects in Explaining Achievement Gains

	Mathematics				Reading			
Included explanatory variables								
Student Covariates	yes	yes	yes	yes	yes	yes	yes	yes
Teacher Characteristics	no	yes	no	no	no	yes	no	no
Teacher Fixed Effects	no	no	yes	no	no	no	yes	no
School Fixed Effects	no	no	no	yes	no	no	no	yes
R Squared	0.0115	0.0147	0.1632	0.0978	0.0118	0.0129	0.1348	0.0855
Observations		80,567				23,464		

Notes: Dependent variables are mathematics and reading test score gains; sample includes only grades in a school with a single teacher for that subject.

Table 3. Effect of Teacher Turnover on the Divergence of Mathematics and Reading Test Score Gains Between Cohorts (standard errors in parentheses)

	no fixed effects[a]	individual and school fixed effects[b]	individual and school-by-grade fixed effects[c]	individual and school fixed effects[b]	individual and school-by-grade fixed effects[c]
1. Mathematics					
proportion of teachers who are different/number of teachers	.077 (0.017)	0.087 (0.015)	0.049 (0.021)	0.078 (0.016)	0.045 (0.021)
absolute change in proportion of teachers with no experience				0.034 (0.016)	0.025 (0.022)
2. Reading					
proportion of teachers who are different/number of teachers	0.100 (0.016)	0.103 (0.019)	0.089 (0.023)	0.098 (0.019)	0.084 (0.024)
absolute change in proportion of teachers with no experience				0.018 (0.017)	0.025 (0.021)

Notes: All equations include the inverse of the number of students, numbers of new principals and superintendents in the school during adjacent years, a grade 7 dummy variable and a cohort dummy variable. The sample includes all students who remain in the same school for grades 5 and 6 (or 6 and 7). Sample size is 3,103 for the mathematics and 3,201 for the reading specifications.

Equations have the same structure for mathematics and for reading. (The analysis of gain patterns between grade 6 and 7 take the same form as those for grades 5 and 6 that are shown). For Θ=proportion different math (or reading) teachers/#teachers: The specifications take the following forms:

a. $\quad (\bar{A}_5^c - \bar{A}_5^{c'})^2 = \beta_\theta \Theta_{6s}^{c,c'} + \beta_X X_{6s}^{c,c'} + e_{6s}^{c,c'}$

b. $\quad [(\bar{A}_6^c - \bar{A}_5^c) - (\bar{A}_6^{c'} - \bar{A}_5^{c'})]^2 = \beta_\theta \Theta_{5 and 6,s}^{c,c'} + \beta_X X_{5 and 6,s}^{c,c'} + e_{5 and 6,s}^{c,c'}$

c. $\quad [(\bar{A}_6^c - \bar{A}_5^c) - (\bar{A}_6^{c'} - \bar{A}_5^{c'})]^2 = \beta_\theta \Theta_{5 and 6,s}^{c,c'} + \sum \omega_s + \beta_X X_{5 and 6,s}^{c,c'} + e_{5 and 6,s}^{c,c'}$

where the fixed effect ω_s=1

for school s and $=0$ otherwise.

Table 4. Effect of Teacher Turnover on the Divergence of Mathematics and Reading Test Score Gains Between Cohorts, Controlling for Teacher Turnover in Other Subjects[a]
(standard errors in parentheses)

	individual and school fixed effects[b]			individual and school-by-grade fixed effects[b]		
1. Mathematics						
proportion different math teachers/number of teachers	0.070 (0.016)	0.068 (0.016)	0.071 (0.016)	0.031 (0.022)	0.033 (0.022)	0.033 (0.022)
absolute change in proportion math teachers with no experience			-0.009 (0.013)			0.009 (0.020)
Proportion of same English teachers		-0.008 (0.012)	-0.008 (0.012)		0.018 (0.018)	0.018 (0.018)
2. Reading						
proportion different English teachers/number of teachers	0.068 (0.028)	0.063 (0.029)	0.044 (0.030)	-0.010 (0.039)	-0.016 (0.039)	-0.013 (0.039)
absolute change in proportion English teachers with no experience			0.045 (0.020)			-0.036 (0.027)
Proportion of same mathematics teachers		-0.018 (0.011)	-0.016 (0.011)		-0.021 (0.013)	-0.022 (0.013)

Notes:
a. The sample includes all students who remain in the same school for grades 5 and 6 (or 6 and 7) in schools with no teacher offering both English and math instruction. All equations include the inverse of the number of students, numbers of new principals and

superintendents in the school during adjacent years, a grade 7 dummy variable and a cohort dummy variable. The sample size is 846.

b. Table 3 notes describe the estimation specifications.

Table 5. Grade Differences in the Effects of Teacher Turnover on the Divergence of Mathematics and Reading Test Score Gains Between Cohorts (standard errors in parentheses)[a]

	individual and school fixed effects	individual and school-by-grade fixed effects	individual and school fixed effects	individual and school-by-grade fixed effects
1. Mathematics				
proportion of teachers who are different/number of teachers	0.109 (0.018)	0.061 (0.026)	0.105 (0.018)	0.053 (0.026)
6&7th grades interaction with proportion different[b]	-0.070 (0.031)	-0.036 (0.044)	-0.072 (0.031)	-0.029 (0.044)
absolute change in proportion of teachers with no experience			0.028 (0.023)	0.043 (0.033)
6&7th grades interaction with absolute change[b]			0.019 (0.039)	-0.022 (0.054)
2. Reading				
proportion of teachers who are different/number of teachers	0.118 (0.021)	0.111 (0.026)	0.116 (0.021)	0.105 (0.027)
6&7th grades interaction with proportion different[b]	-0.074 (0.043)	-0.103 (0.057)	-0.091 (0.045)	-0.100 (0.058)
absolute change in proportion of teachers with no experience			0.008 (0.021)	0.033 (0.027)
6&7th grades interaction with absolute change[b]			0.036 (0.037)	-0.020 (0.044)

a. Table 3 notes describe the sample and estimation specifications.

b. Interaction between an indicator for the grade 6&7 observations and specified variable.

Table 6. Probability of Exiting a School by Quality of Instruction Relative to Others in the School for Teachers in a Large Texas District

Quality index	Frequency (percent)	Exit rate (percent)
-1.56	0.17	42.9
-1.41	0.20	11.8
-1.27	0.45	23.7
-1.11	0.56	23.4
-0.94	1.17	30.6
-0.79	1.73	26.2
-0.63	2.86	22.2
-0.48	5.08	22.6
-0.32	9.58	21.3
-0.16	15.29	20.6
-0.01	21.35	20.2
0.14	16.65	17.65
0.29	10.58	18.51
0.45	6.51	18.35
0.60	3.55	12.79
0.76	2.07	17.34
0.92	0.96	25.00
1.07	0.62	13.46
1.22	0.43	13.89
1.38	0.19	0.00

Notes: The sample includes all teachers in grades 4-8 in one large Texas district. The measure of quality is the difference between average student gain in mathematics for a teacher and the average gain for all other teachers in the school. These relative gains are divided into 20 equal intervals, and the index for each interval is the interval mean. Frequency is the proportion of all teachers in the city in the category, and Exit probability is the fraction of teachers who leave the school at the end of the year.

Table 7. Effects of Teacher Characteristics on 4th-7th Grade Gains in Mathematics and Reading Test Scores (robust standard errors in parentheses; 1,339,238 observations)

	no fixed effects	student and school fixed effects	student and school-by-year fixed effects	student, school by grade and school-by-year fixed effects
1. Mathematics				
class size				
4th grade	-0.0042	-0.0113	-0.0120	n.a.
	(0.0023)	(0.0041)	(0.0043)	
5th grade	-0.0032	-0.0088	-0.0088	-0.0117
	(0.00099)	(0.0018)	(0.0027)	(0.0036)
6th grade	-0.0006	-0.0040	-0.0050	-0.0044
	(0.0010)	(0.0018)	(0.0022)	(0.0023)
7th grade	0.0009	0.0021	0.0012	0.0006
	(0.0009)	(0.0021)	(0.0023)	(0.0026)
Experience				
proportion 0 years	-0.072	-0.087	-0.099	-0.065
	(0.011)	(0.020)	(0.025)	(0.029)
proportion 1 year	-0.034	-0.062	-0.074	0.014
	(0.012)	(0.021)	(0.026)	(0.029)
proportion 2 years	-0.019	-0.034	-0.030	-0.013
	(0.012)	(0.023)	(0.028)	(0.030)
proportion 3-5 years	-0.013	-0.028	-0.031	-0.024
	(0.010)	(0.018)	(0.024)	(0.027)
Education				
proportion with graduate degree	-0.018	-0.019	-0.029	-0.11
	(0.008)	(0.016)	(0.019)	(0.027)

Table 7. Continued

	no fixed effects	student and school fixed effects	student and school-by-year fixed effects	student, school by grade and school-by-year fixed effects
2. Reading				
class size				
4th grade	-0.0025	-0.0084	-0.0106	n.a.
	(0.0017)	(0.0031)	(0.0033)	
5th grade	0.0005	-0.0029	-0.0033	-0.0139
	(0.0007)	(0.0013)	(0.0020)	(0.0038)
6th grade	0.0021	-0.0006	-0.0015	-0.0032
	(0.0008)	(0.0014)	(0.0016)	(0.0028)
7th grade	-0.0043	-0.0037	-0.0039	-0.0010
	(0.0008)	(0.0018)	(0.0020)	(0.0033)
Experience				
proportion 0 years	-0.055	-0.073	-0.085	0.0310
	(0.010)	(0.019)	(0.025)	(0.040)
proportion 1 year	-0.042	-0.051	-0.084	-0.002
	(0.010)	(0.019)	(0.025)	(0.042)
proportion 2 years	-0.018	-0.029	-0.045	0.070
	(0.011)	(0.020)	(0.027)	(0.042)
proportion 3-5 years	-0.003	-0.007	-0.023	0.060
	(0.009)	(0.017)	(0.021)	(0.038)
Education				
proportion with graduate degree	-0.022	-0.017	-0.003	0.059
	(0.007)	(0.014)	(0.015)	(0.036)

| Observations | 1,358,853 | 1,358,853 | 1,358,853 | 1,358,853 |

Note: All specifications include a full set of grade-by-year dummies and indicators for subsidized lunch eligibility and a change of school prior to or during year. Robust standard errors in Tables 7, 8, and 9 are clustered at the school level to correct for correlations among the unobservables of students attending the same school. Only the standard errors in the full fixed effect model in the final column of Table 7 are not clustered by school.

Table 8. Effects of Class Size on Test Score Gains, by Family Income (robust standard errors in parentheses)

class size	Mathematics		Reading	
	disadvantaged students	not disadvantaged students	disadvantaged students	not disadvantaged students
4th grade	-0.0133	-0.0112	-0.0124	-0.0094
	(0.0044)	(0.0043)	(0.0034)	(0.0033)
5th grade	-0.0089	-0.0085	-0.0034	-0.0031
	(0.0028)	(0.0027)	(0.0021)	(0.0020)
6th grade	-0.0050	-0.0049	-0.0032	-0.0016
	(0.0023)	(0.0022)	(0.0017)	(0.0016)
7th grade	0.0011	0.0011	-0.0006	-0.0049
	(0.0024)	(0.0023)	(0.0021)	(0.0020)

Note: Estimates come from a single mathematics regression and a single reading regression. The models include student and school-by-year fixed effects, separate class size and teacher experience variables for students eligible for a subsidized lunch (disadvantaged) and those not eligible during a given school year, proportion of teachers with a graduate degree, full sets of grade-by-year dummies, and indicators for subsidized lunch eligibility and a change of school prior to or during year.

Table 9. Effects of Teacher Experience on Mathematics and Reading Test Score Gains, by New Teacher Transitions
(robust standard errors in parentheses)

	excluding teachers who exit or switch schools	excluding teachers who exit teaching	all teachers
Proportion 0 years experience			
math	-0.064	-0.071	-0.090
	(0.026)	(0.024)	(0.020)
Observations	[1,218,996]	[1,256,079]	[1,339,238]
reading	-0.073	-0.073	-0.075
	(0.024)	(0.022)	(0.019)
Observations	[1,238,943]	[1,275,773]	[1,358,853]

Note: Estimates come from a model that includes student and school fixed effects. Specifications also include the percentage of teachers with a graduate degree, full sets of class size variables and grade-by-year dummies and indicators for subsidized lunch eligibility and a change of school prior to or during year.

Appendix Table C1. Teacher quality standard deviation estimates calculated from squared difference in quality for periods 0 and 1, based on observed distributions of teacher quality and departure rates.

Number of teacher quality intervals	σ assuming random departures	σ assuming empirical distribution of departures
20 (above table)	0.395	0.399
40	0.397	0.401
60	0.397	0.402
30 with tails	0.422	0.427

Appendix Table C2. Effect of Teacher Turnover on the Divergence of Gains in Mathematics and Reading Test Scores Between Cohorts for Schools with One Teacher per Grade (standard errors in parentheses)

	no fixed effects	individual and school fixed effects	individual and school-by-grade fixed effects
1. Mathematics proportion different math teachers/number of teachers	0.118 (0.039)	0.121 (0.039)	0.044 (0.047)
2. Reading proportion different English teachers/ number of teachers	0.165 (0.064)	0.048 (0.070)	0.122 (0.104)

Notes: All equations include the inverse of the number of students, numbers of new principals and superintendents in the school during adjacent years, and a cohort dummy variable. Sample size is 302 for the mathematics and 84 for the reading specifications. Table 3 notes describe the estimation specifications.

Appendix Table B1. Variable Means and Standard Deviations (class size and teacher characteristics come from mathematics sample)

	math test score gain	reading test score gain	class size	teacher characteristics % with graduate degree	% 0 years experience	% 1 year experience	observations
4th grade	-.01 (0.71)	-0.03 (0.73)	19.5 (2.3)	24.0 (26.1)	7.0 (14.8)	6.8 (14.4)	144,358
5th grade	0.01 (0.64)	0.01 (0.68)	22.6 (3.5)	25.3 (28.1)	6.9 (16.2)	5.7 (14.3)	437,749
6th grade	0.05 (0.60)	0.05 (0.67)	22.2 (3.9)	24.2 (28.6)	8.2 (18.5)	7.7 (17.7)	456,311
7th grade	0.02 (0.54)	0.03 (0.65)	21.5 (4.1)	22.1 (28.4)	9.9 (20.0)	9.6 (19.2)	300,820