Online Appendix

Engaging Teachers:
Measuring the Impact of Teachers on Student Attendance in Secondary School
Jing Liu and Susanna Loeb

Appendix A: List of covariates included in models

Prior math test score (standardized)
Prior ELA test score (standardized)
Prior absence rate in math
Prior absence rate in ELA
Black
Hispanic
Asian
Female
English learner status
Special education status
Gifted education status
Prior suspensions
Current math test
Prior math test
Class average prior math test score
Class average prior reading test score
Class average prior absence rate
Class average prior suspensions
Class percentage black
Class percentage Hispanic
Class percentage Asian
Class percentage English learners
Class periods
School percentage black
School percentage Hispanic
School percentage Asian
School percentage English learners
School average prior absence rate
School average prior suspensions

Appendix B: Regression results of estimating value-added to attendance for math teachers

	Coefficient		Standard Error
% Any absence_math_lag	1.500	**	0.103
% Any absence_ELA_lag	1.734	**	0.098
Any absence_lag	4.982	**	0.102
Test score_math_lag (standardized)	-0.170	**	0.006
Test score_ELA_lag (standardized)	-0.039	**	0.006
Suspension days_lag	0.020	**	0.004
Black	0.159	**	0.014
Hispanics	0.099	**	0.011
Asian	-0.356	**	0.009
Female	-0.067	**	0.006
Special Education	-0.113	**	0.014
Gifted	-0.027	**	0.009
EL	0.046	**	0.011
Class black	0.129	*	0.064
Class Hispanics	-0.059		0.053
Class Asian	-0.087	+	0.047
Class EL	3.424	**	0.763
Class math test score_lag	-0.244	**	0.018
Class ELA test score_lag	-0.020		0.017
Class absence_lag	-0.083		0.148
Class suspension_lag	-0.005		0.015
School black	-0.553	*	0.232
School Hispanics	-0.508	**	0.173
School Asian	-0.388	*	0.160
School EL	0.335	**	0.104
School absence_lag	2.776	**	0.441
School suspension_lag	-0.188	**	0.054
grade = 8	0.018		0.017
grade = 9	0.586	**	0.057
grade = 10	0.294	**	0.072
grade = 11	0.378	**	0.075
Period = 2	-0.304	**	0.012
Period = 3	-0.345	**	0.012
Period = 4	-0.313	**	0.012
Period = 5	-0.268	**	0.013
Period = 6	-0.190	**	0.012
Period = 7	0.010		0.016

Period = 8	-0.048		0.059
Constant	-4.631	**	0.195
ln(total)	1.000		(exposure)
/lnalpha	-0.217		0.006
var(_cons)	0.200		0.007

Appendix C: Estimating value-added to attendance using NBRM and controlling for school fixed effects

Table C1. Magnitude of Teacher Effects on Class Unexcused Absences

		Standard Deviation	Incidence Rate Ratio
Teacher	Math	0.280	1.324
	ELA	0.352	1.422
	Science	0.322	1.380
	Social Studies	0.310	1.363
	Foreign Languages	0.281	1.325
Teacher by Year	Math	0.361	1.435
	ELA	0.393	1.482
	Science	0.377	1.458
	Social Studies	0.382	1.465
	Foreign Languages	0.330	1.392

Table C2. Transition Matrix: VA to Attendance

		Quintile of Future Performance on Attendance					
Initial Quintile		Q1	Q2	Q3	Q4	Q5	Row
Q1	n	27	15	21	15	1	79
	(row %)	(34.18)	(18.99)	(26.58)	(18.99)	(1.27)	(100)
Q2	n	24	17	16	11	9	77
	(row %)	(31.17)	(22.08)	(20.78)	(14.29)	(11.69)	(100)
Q3	n	15	30	12	12	9	78
	(row %)	(19.23)	(38.46)	(15.38)	(15.38)	(11.54)	(100)
Q4	n	7	7	19	25	19	77
	(row %)	(9.09)	(9.09)	(24.68)	(32.47)	(24.68)	(100)
Q5	n	6	8	10	14	39	77
	(row %)	(7.79)	(10.39)	(12.99)	(18.18)	(50.65)	(100)
Column Total		79	77	78	77	77	**388**

Table C3. Adjusted R-Squared Using Early Year VA to Predict Future Performance

	Outcome (Attendance)			
Early Year VA Predictor(s)	VA in Y3	VA in Y4	VA in Y5	Mean(VA_{Y3-5})
Math				
Math VA in Y1 Only	0.030	0.064	0.000	0.065
Math VA in Y2 Only	0.028	0.102	0.023	0.083
Math VA in Y1 & Y2	0.043	0.129	0.019	0.115
ELA				
ELA VA in Y1 Only	0.037	0.037	0.002	0.040
ELA VA in Y2 Only	0.096	0.025	0.001	0.060
ELA VA in Y1 & Y2	0.102	0.044	0.000	0.075

Appendix D: Joint estimates of value-added to attendance and value-added to achievement

The purpose of this model is to get the true correlation between the two types of value-added scores through running this joint model. We cannot run a negative binomial model in this case, thus we reconstruct the unexcused absence outcome to unexcused absence rate (standardized by year and grade). Then we create a variable called "Outcome" and two indicator variables, "TestScore" and "Absence." "Outcome" takes the values of test scores when the dummy variable "TestScore" equals 1, and takes the values of unexcused absence rate when the dummy variable "Absence" equals 1.

We estimate the model is below.
Level 1:

$$Outcome_{ijt} = \beta_{1j}(TestScore_{ijt}) + \beta_{2j}(Absence_{ijt}) + (TestScore_{ijt})X'_{ijt}\emptyset_T + (Absence_{ijt})X'_{ijt}\emptyset_A + e_{ijt}$$

Where $e_{ijt} \sim \mathrm{N}(0, \sigma^2)$

Level 2:

$$\beta_{1j} = \gamma_{10} + \mu_{1j}$$
$$\beta_{2j} = \gamma_{20} + \mu_{2j}$$

Where $\begin{pmatrix}\mu_{1j}\\ \mu_{2j}\end{pmatrix} \sim N\left(\begin{matrix}0\\ 0\end{matrix}, \begin{pmatrix}\tau_1 & \tau_{2,1}\\ \tau_{1,2} & \tau_2\end{pmatrix}\right)$

We constrain the above model to have no intercept, so that both of the indicator variables will contain a random teacher effect. The random teacher effects are assumed to have a mean of zero and a variance to be estimated. We interact all of the controls with these two indicators so that these controls can have differential effects for test scores and absences.

Appendix E: Non-linearities and Heterogeneity of Teacher Effectiveness

Table E1. Effects of Out of Sample Teacher Effects on Long-Term Outcomes: Nonlinearity

	(1) Graduation	(2) Dropout Before 12th Grade	(3) Number of AP Courses	(4) Earned Credits of AP Courses
Test Score VA				
Decile 1	-0.00558	0.00285	-0.00434	-0.03474
	(0.00383)	(0.00261)	(0.00766)	(0.03804)
Decile 2	-0.00637+	0.00233	0.03345**	0.15855**
	(0.00334)	(0.00224)	(0.00749)	(0.03724)
Decile 3	-0.00400	0.00084	-0.01088	-0.06399+
	(0.00319)	(0.00214)	(0.00731)	(0.03635)
Decile 4	-0.00577+	0.00426*	0.01109	0.04381
	(0.00308)	(0.00209)	(0.00703)	(0.03495)
Decile 6	0.00360	-0.00141	0.02172**	0.10217**
	(0.00298)	(0.00196)	(0.00690)	(0.03429)
Decile 7	-0.00311	0.00517**	0.04939**	0.23487**
	(0.00292)	(0.00196)	(0.00699)	(0.03476)
Decile 8	-0.00134	0.00056	0.02547**	0.11978**
	(0.00303)	(0.00201)	(0.00749)	(0.03724)
Decile 9	-0.00362	0.00386+	0.03511**	0.16641**
	(0.00323)	(0.00217)	(0.00791)	(0.03941)
Decile 10	-0.00852*	0.00347	0.05280**	0.25544**
	(0.00383)	(0.00259)	(0.00923)	(0.04600)
Attendance VA				
Decile 1	(0.00383)	(0.00259)	(0.00923)	(0.04600)
	-0.00558	0.00285	-0.00434	-0.03474
Decile 2	(0.00383)	(0.00261)	(0.00766)	(0.03804)
	-0.00637+	0.00233	0.03345**	0.15855**
Decile 3	(0.00334)	(0.00224)	(0.00749)	(0.03724)
	-0.00400	0.00084	-0.01088	-0.06399+
Decile 4	(0.00319)	(0.00214)	(0.00731)	(0.03635)
	-0.00577+	0.00426*	0.01109	0.04381
Decile 6	(0.00308)	(0.00209)	(0.00703)	(0.03495)
	0.00360	-0.00141	0.02172**	0.10217**
Decile 7	(0.00298)	(0.00196)	(0.00690)	(0.03429)
	-0.00311	0.00517**	0.04939**	0.23487**
Decile 8	(0.00292)	(0.00196)	(0.00699)	(0.03476)
	-0.00134	0.00056	0.02547**	0.11978**

Decile 9	(0.00303)	(0.00201)	(0.00749)	(0.03724)
	-0.00362	0.00386+	0.03511**	0.16641**
Decile 10	(0.00323)	(0.00217)	(0.00791)	(0.03941)
	-0.00558	0.00285	-0.00434	-0.03474
	(0.00383)	(0.00261)	(0.00766)	(0.03804)
Observations	211183	211183	211183	211183
Adjusted R2	0.215	0.109	0.308	0.307

Note: Each column reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both the number and credits of AP courses only include those taken in 12^{th} grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; subject fixed effects; and school fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Table E2. Effects of Out of Sample Teacher Effects on Long-Term Outcomes: By Tertiles of Prior Attendance/Achievement

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Tertiles of Prior Attendance			Tertiles of Prior Math Scores			Tertiles of Probability of Graduation		
	Bottom	Middle	Top	Bottom	Middle	Top	Bottom	Middle	Top
	Graduation								
Test Score VA	0.00256	0.00083	-0.00002	0.00566**	-0.00133	0.00099	0.00466*	0.00296+	-0.00054
	(0.00225)	(0.00181)	(0.00141)	(0.00218)	(0.00183)	(0.00144)	(0.00230)	(0.00179)	(0.00117)
Attendance VA	0.01130**	0.00517*	0.00222	0.01365**	0.00695**	0.00281+	0.01280**	0.00556**	0.00233+
	(0.00299)	(0.00216)	(0.00145)	(0.00291)	(0.00208)	(0.00153)	(0.00314)	(0.00206)	(0.00125)
Adjusted R2	0.187	0.125	0.073	0.198	0.142	0.093	0.151	0.081	0.038
	Dropout before 12th Grade								
Test Score VA	-0.00126	-0.00112	0.0002	-0.00134	-0.00042	-0.00072	-0.00366*	0.00125	-0.00038
	(0.00171)	(0.00117)	(0.00078)	(0.00157)	(0.00123)	(0.00092)	(0.00169)	(0.00115)	(0.00070)
Attendance VA	-0.00468*	-0.00087	-0.00056	-0.00505*	-0.00108	-0.00175+	-0.00280	-0.00358**	-0.00048
	(0.00220)	(0.00142)	(0.00082)	(0.00210)	(0.00135)	(0.00098)	(0.00229)	(0.00127)	(0.00081)
Adjusted R2	0.114	0.053	0.032	0.12	0.074	0.051	0.111	0.045	0.023
	Number of AP Courses								
Test Score VA	0.01260**	0.01709**	0.03067**	0.00841**	0.01939**	0.03153**	0.00480**	0.01965**	0.03155**
	(0.00276)	(0.00415)	(0.00511)	(0.00193)	(0.00376)	(0.00600)	(0.00185)	(0.00389)	(0.00595)
Attendance VA	0.01433**	0.01252*	-0.00636	0.00522*	-0.00651	-0.01441*	0.01011**	-0.00822+	-0.02171**
	(0.00392)	(0.00524)	(0.00595)	(0.00254)	(0.00444)	(0.00702)	(0.00252)	(0.00457)	(0.00674)
Adjusted R2	0.215	0.278	0.306	0.161	0.201	0.277	0.107	0.173	0.284
	Credits of AP Courses								
Test Score VA	0.06572**	0.08179**	0.15146**	0.04274**	0.09195**	0.15885**	0.02292*	0.09894**	0.15555**
	(0.01355)	(0.02060)	(0.02555)	(0.00942)	(0.01866)	(0.02996)	(0.00899)	(0.01925)	(0.02975)
Attendance VA	0.07091**	0.06616*	-0.02842	0.02523*	-0.03174	-0.06707+	0.05180**	-0.03870+	-0.10442**
	(0.01940)	(0.02604)	(0.02968)	(0.01241)	(0.02200)	(0.03503)	(0.01230)	(0.02267)	(0.03364)
Adjusted R2	0.214	0.277	0.305	0.155	0.198	0.277	0.105	0.170	0.283

Observations	64366	66139	67134	62434	66388	68817	62787	66397	68455

Note: Each column, within panels, reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both number and credits of AP courses only include those taken in 12^{th} grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Table E3. Effects of Out of Sample Teacher Effects on Long-Term Outcomes: By Chronic Absenteeism Status, Gender, and Race

	(1) Chronically Absent	(2) Not Chronically Absent	(3) Female	(4) Male	(5) Black/Hispanic	(6) White/Asian
			Graduation			
Test Score VA	0.00166	0.00020	0.00024	0.00064	0.00559*	-0.00150
	(0.00308)	(0.00114)	(0.00150)	(0.00162)	(0.00240)	(0.00122)
Attendance VA	0.01218**	0.00584**	0.00678**	0.00819**	0.00977**	0.00816**
	(0.00420)	(0.00128)	(0.00173)	(0.00186)	(0.00326)	(0.00132)
Adjusted R2	0.194	0.154	0.198	0.215	0.191	0.123
			Dropout			
Test Score VA	-0.00010	-0.00040	-0.00035	-0.00006	-0.00248	0.00097
	(0.00243)	(0.00073)	(0.00106)	(0.00111)	(0.00185)	(0.00073)
Attendance VA	-0.00565+	-0.00163+	-0.00328**	-0.00258*	-0.00349	-0.00393**
	(0.00317)	(0.00084)	(0.00119)	(0.00127)	(0.00243)	(0.00081)
Adjusted R2	0.136	0.070	0.101	0.113	0.111	0.054
			Number of AP Course			
Test Score VA	0.00721*	0.02417**	0.02503**	0.02071**	0.01234**	0.02596**
	(0.00308)	(0.00284)	(0.00360)	(0.00317)	(0.00275)	(0.00350)
Attendance VA	0.02290**	0.00372	0.00564	0.01543**	0.00595	0.00005
	(0.00448)	(0.00355)	(0.00458)	(0.00417)	(0.00372)	(0.00425)
Adjusted R2	0.201	0.300	0.306	0.299	0.184	0.302
			Credits of AP Courses			
Test Score VA	0.03422*	0.12060**	0.12328**	0.10404**	0.06007**	0.12879**
	(0.01499)	(0.01415)	(0.01793)	(0.01578)	(0.01349)	(0.01745)
Attendance VA	0.11184**	0.02172	0.03272	0.07761**	0.03036+	0.00239
	(0.02196)	(0.01768)	(0.02284)	(0.02072)	(0.01828)	(0.02120)
Adjusted R2	0.198	0.299	0.306	0.297	0.181	0.301

Observations	35540	162099	96317	101322	52063	127302

Note: Each column, within panels, reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both number and credits of AP courses only include those taken in 12^{th} grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Appendix F: Estimating value-added to attendance using OLS

As we describe in the Methods section, students can have different "exposure" times to a teacher during a school year, thus we cannot directly do a logarithm transformation of the raw counts of absences as the dependent variable in the OLS model. Instead, we calculate the rate of unexcused absences overall total class meetings a student can have with a teacher.

As shown below, value-added to attendance using OLS is similarly stable compared with those from NBRM (see Table F1 and F2 for results in keeping with Tables 4 and 5). However, they do not show as consistent relationships with student short- and long-run outcomes. Table F3 (similar to Table 6) shows that value-added to attendance has a negative impact students' unexcused absence rate which is consistent with the NBRM results, but it also has a negative effect on student test scores, which is not consistent with the NBRM results. Similarly, in Table F4 (mirroring Table 7), it positively affects student graduation but negatively affects AP course taking. Tables E5 and E6 shows results that are quite similar to Tables 8 and 9.

To assess whether the inconsistencies in the two approaches stem from predictable shortcomings in the OLS approach, we remove teachers who are in the top quartile of having zero-absence students (approximately 35% of zero-absence students in total students a teacher has) from the analysis. Because OLS estimates a linear relationship, these students could have negative predicted absenteeism so that the residual will be positive (negative on attendance). We then replicate Table F4-a, and show the corresponding results in Table F4-b. We find that the results from the OLS and NBRM models largely converge when we remove these teachers.

Table F1. Transition Matrix: VA to Attendance

		Quintile of Future Performance on Attendance					
Initial Quintile		Q1	Q2	Q3	Q4	Q5	Row
Q1	n	38	21	9	10	2	80
	(row %)	(47.50)	(26.25)	(11.25)	(12.50)	(2.50)	(100)
Q2	n	17	26	22	8	7	80
	(row %)	(21.25)	(32.50)	(27.50)	(10.00)	(8.75)	(100)
Q3	n	8	12	23	26	10	79
	(row %)	(10.13)	(15.19)	(29.11)	(32.91)	(12.66)	(100)
Q4	n	13	17	14	17	19	80
	(row %)	(16.25)	(21.25)	(17.50)	(21.25)	(23.75)	(100)
Q5	n	4	4	11	19	41	79
	(row %)	(5.06)	(5.06)	(13.92)	(24.05)	(51.90)	(100)
Column Total		79	77	78	77	77	**388**

Table F2. Adjusted R-Squared Using Early Year VA to Predict Future Performance

	Outcome (Attendance)			
Early Year VA Predictor(s)	VA in Y3	VA in Y4	VA in Y5	Mean(VA_{Y3-5})
Math				
Math VA in Y1 Only	0.108	0.053	0.076	0.138
Math VA in Y2 Only	0.096	0.104	0.088	0.181
Math VA in Y1 & Y2	0.158	0.124	0.126	0.253
ELA				
ELA VA in Y1 Only	0.129	0.084	0.013	0.121
ELA VA in Y2 Only	0.359	0.265	0.125	0.361
ELA VA in Y1 & Y2	0.368	0.268	0.121	0.368

Table F3. Effects of Out of Sample Teacher Effects on Current Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
		Test Scores			Unexcused Absence Rate	
Test Score VA	0.10866**		0.10969**	-0.00071**		-0.00050**
	(0.00181)		(0.00182)	(0.00015)		(0.00015)
Attendance VA		-0.01439**	-0.01942**		-0.00404**	-0.00402**
		(0.00166)	(0.00165)		(0.00017)	(0.00017)
Observations	223623	223623	223623	223623	223623	223623
Adjusted R-squared	0.659	0.653	0.659	0.428	0.430	0.430

Note: Each column reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Dependent variables are current test scores and unexcused absence rates. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year, subject, and school fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** p<0.01, * p<0.05, + p<0.10.

Table F4-a. Effects of Out of Sample Teacher Effects on Long-Term Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
		Graduation			Dropout Before 12th Grade	
Test Score VA	0.00100		0.00086	-0.00028		-0.00025
	(0.00129)		(0.00129)	(0.00090)		(0.00090)
Attendance VA		0.00299*	0.00295*		-0.00071	-0.00070
		(0.00127)	(0.00128)		(0.00089)	(0.00089)
Observations	197639	197639	197639	197639	197639	197639
Adjusted R2	0.208	0.208	0.208	0.107	0.107	0.107
		Number of AP Courses			Credits of AP Courses	
Test Score VA	0.02490**		0.02544**	0.12334**		0.12607**
	(0.00306)		(0.00306)	(0.01522)		(0.01523)
Attendance VA		-0.01048**	-0.01151**		-0.05314**	-0.05824**
		(0.00239)	(0.00239)		(0.01188)	(0.01187)
Observations	197639	197639	197639	197639	197639	197639
Adjusted R2	0.306	0.306	0.306	0.305	0.305	0.305

Note: Each column, within panels, reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both the number and credits earned for AP courses only include those taken in 12th grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** p<0.01, * p<0.05, + p<0.10.

Table F4-b. Effects of Out of Sample Teacher Effects on Long-Term Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
		Graduation			Dropout Before 12th Grade	
Test Score VA	0.00189		0.00081	-0.00139		-0.00094
	(0.00166)		(0.00167)	(0.00114)		(0.00115)
Attendance VA		0.01200**	0.01191**		-0.00515**	-0.00505**
		(0.00182)	(0.00183)		(0.00119)	(0.00121)
Observations	144415	144415	144415	144415	144415	144415
Adjusted R2	0.219	0.219	0.219	0.116	0.116	0.116
		Number of AP Courses			Credits of AP Courses	
Test Score VA	0.01521**		0.01497**	0.07551**		0.07388**
	(0.00328)		(0.00329)	(0.01629)		(0.01630)
Attendance VA		0.00442	0.00269		0.02656	0.01802
		(0.00381)	(0.00381)		(0.01892)	(0.01893)
Observations	144415	144415	144415	144415	144415	144415
Adjusted R2	0.281	0.281	0.281	0.280	0.280	0.280

Note: The data used are the same as Table F4-A except excluding teachers who are in the top quartile of having zero-absence students. Each column, within panels, reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both the number and credits earned for AP courses only include those taken in 12th grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** p<0.01, * p<0.05, + p<0.10.

Table F5. Effects of Out of Sample Teacher Effects on Long-Term Outcomes: Nonlinearity

	(1)	(2)	(3)	(4)
	Graduation	Dropout Before 12th Grade	Number of AP Courses	Earned Credits of AP Courses
Test Score VA	0.00333+	-0.00096	0.03429**	0.16986**
	(0.00172)	(0.00120)	(0.00365)	(0.01816)
Test Score VA_Squared	-0.00028	-0.00053	0.02567**	0.12540**
	(0.00149)	(0.00107)	(0.00273)	(0.01357)
Attendance VA	0.00702**	-0.00545**	0.03918**	0.19712**
	(0.00111)	(0.00077)	(0.00277)	(0.01379)
Attendance VA_Squared	-0.00269**	0.00053+	-0.00357**	-0.01764**
	(0.00044)	(0.00031)	(0.00094)	(0.00471)
Observations	197639	197639	197639	197639
Adjusted R2	0.205	0.104	0.286	0.285

Note: Each column reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both the number and credits of AP courses only include those taken in 12th grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** p<0.01, * p<0.05, + p<0.10.

Table F6. Effects of Out of Sample Teacher Effects on Long-Term Outcomes: By Tertiles of Prior Attendance/Achievement

	Graduation	Dropout Before 12th Grade	Number of AP Courses	Earned Credits of AP Courses	Graduation	Dropout Before 12th Grade	Number of AP Courses	Credits of AP Courses
Panel A. Tertiles of prior attendance								
		Bottom tertile of attendance				Top tertile of attendance		
Test Score VA	0.00632+	-0.00254	0.02506**	0.12826**	0.00248	-0.00016	0.02957**	0.21589**
	(0.00342)	(0.00261)	(0.00422)	(0.02071)	(0.00219)	(0.00121)	(0.00682)	(0.04023)
Attendance VA	0.00848**	-0.00540**	0.03340**	0.16778**	-0.00076	-0.00178*	0.00012	0.02019
	(0.00237)	(0.00178)	(0.00361)	(0.01786)	(0.00134)	(0.00075)	(0.00367)	(0.02494)
Observations	64366	64366	64366	64366	67134	67134	67134	67134
Adjusted R-squared	0.184	0.111	0.195	0.193	0.068	0.028	0.286	0.286
Panel B. Tertiles of prior math scores								
		Bottom tertile of math scores				Top tertile of math scores		
Test Score VA	0.01378**	-0.00422+	0.01968**	0.09599**	0.00324	-0.00231+	0.04323**	0.21842**
	(0.00331)	(0.00241)	(0.00302)	(0.01472)	(0.00222)	(0.00140)	(0.00943)	(0.04709)
Attendance VA	0.01274**	-0.00628**	0.00582**	0.02841**	-0.00039	-0.00370**	0.00325	0.01889
	(0.00236)	(0.00175)	(0.00197)	(0.00961)	(0.00139)	(0.00087)	(0.00570)	(0.02848)
Observations	62434	62434	62434	62434	68817	68817	68817	68817
Adjusted R-squared	0.195	0.117	0.145	0.140	0.089	0.048	0.258	0.258

Note: Each column, within panels, reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using the stacked sample that pools together both math and ELA for 7th to 11th graders. Both number and credits of AP courses only include those taken in 12th grade to avoid mechanical endogeneity. All columns control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** p<0.01, * p<0.05, + p<0.10.

Appendix G: Selection on observables

One threat to our identification is that students are selected to teachers based on observed student characteristics. The assumption is that conditional on the controls in our specification, there is no systematic sorting of students to teachers. To test whether this is true, following Chetty et al. (2014) and Jackson (2018), we first use twice lagged student characteristics to predict all the long-term outcomes, which effectively limits our sample to students who have twice-lagged controls and only 8th to 11th graders. The student characteristics used here include test scores and absence rates for both math and ELA classes, days of suspension, race, gender, special education status, gifted status, and EL status. Using predicted outcomes and conditional on all student, class, and school characteristics excluding those used in the prediction, we should not observe any significant association between the estimated teacher value-added (leave-year-out estimates) and the predicted outcomes.

Table G1 presents the results. Columns (1) and (2) show results for using actual graduation, dropout, and AP course taking as outcomes. The results are slightly different from Table 7 because here we are only using 8th to 11th grades in the sample. We still find similar magnitudes and significance of value-added to attendance on all the long-term outcomes. In columns (3) and (4), we use the predicted outcomes as dependent variables. The sample sizes are smaller than columns (1) and (2) because of the reason we described above. We find that the significance of value-added to attendance disappear for predicted graduation and dropout. Although they are significant for predicted number of AP courses and earned AP credits, the magnitudes are so small and nearly negligible, suggesting minimum selection in our model. For value-added to achievement, although we observe significant coefficients for predicted graduation and dropout, but the directions are opposite of what we would sort of sorting. Similar to value-added to attendance, the coefficients of value-added to achievement on predicted AP course are very small and only marginally significant. Our results suggest that our strategy largely eliminate selection on observables.

Table G1. Robustness Check of Selection on Observables

	(1)	(2)	(3)	(4)
	Graduation	Dropout Before 12th Grade	Predicted: Graduation	Predicted: Dropout Before 12th Grade
Test Score VA	0.00268+	-0.00029	-0.00146**	0.00034*
	(0.00156)	(0.00104)	(0.00037)	(0.00016)
Attendance VA	0.00351**	-0.00285**	-0.00027	-0.00002
	(0.00091)	(0.00062)	(0.00021)	(0.00009)

Observations	166136	166136	129252	129252
	Number of AP Courses	Earned Credits of AP Courses	Predicted: Number of AP Courses	Predicted: Earned Credits of AP Courses
Test Score VA	0.02556**	0.12495**	0.00225*	0.01182*
	(0.00354)	(0.01762)	(0.00103)	(0.00514)
Attendance VA	0.04085**	0.20668**	0.00279**	0.01416**
	(0.00229)	(0.01142)	(0.00059)	(0.00293)
Observations	166136	166136	129252	129252

Note: Columns (3) - (4) use predicted graduation, dropout, number of AP courses, and earned credits of AP courses as outcomes. The prediction of graduation and dropout is conducted for each of 8^{th}-11^{th} grade separately using a Logit model. Predictors include twice-lagged math and English scores, test types, absence rates, and suspension, race, gender, special education status, gifted status, and EL status. Each column reports coefficients from an OLS regression, with standard errors clustered at both student and teacher level to account for correlation between observations. The columns are estimated using data pooling across 8th-11th grades and those who have twice-lagged controls. All columns control for the baseline student, class, and school level characteristics but excludes those used in the prediction, which include one-year lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** $p<0.01$, * $p<0.05$, + $p<0.10$.

Appendix H: Selection on unobservables

Following Jackson (2018), we test selection on unobservables based on two distinct sources of variation. The first strategy relies on school-by-cohort fixed effects. Since Jackson (2018) only uses 9th graders, he uses school-by-year fixed effects. Here we modify his approach by using school-by-cohort fixed effects because the selection of students to teachers most likely happens within school-cohort, which is most susceptible to selection on unobservables. This approach should be robust to any school-level policy and shocks. The second strategy uses a Two-Stage Least Square estimator, relying on variation induced by average estimated teacher value-added scores across cohorts within a school. This Instrumental Variable approach is robust to student selection to teachers within a school, but is susceptible to school polices or changes. If these two distinct identification strategies provide similar results, then we have extra evidence to say that our estimation strategy is not biased due to unobservables.

Table H1 present the results using the above two identification strategies. Columns (1) and (2) are from models with school-cohort fixed effects, and (3) and (4) are from models using across cohorts within school value-added as an instrumental variable. The overall magnitude and significance is remarkably consistent with Table 7, especially for value-added to attendance.

Table H1. Robustness Check of Selection on Unobservables

	(1)	(2)	(3)	(4)
	OLS with School-Cohort Fixed Effects		2SLS using Average Teacher Quality in the School-Cohort as an Instrument	
	Graduation	Dropout Before 12th Grade	Graduation	Dropout Before 12th Grade
Test Score VA	-0.00028	0.00015	0.00479	-0.00177
	(0.00152)	(0.00105)	(0.00449)	(0.00302)
Attendance VA	0.00684**	-0.00298**	0.00342*	-0.00684**
	(0.00101)	(0.00068)	(0.00133)	(0.00091)
Observations	197639	197639	197639	197639
	Number of AP Courses	Earned Credits of AP Courses	Number of AP Courses	Earned Credits of AP Courses
Test Score VA	0.02505**	0.12427**	0.01163	0.04948
	(0.00311)	(0.01550)	(0.00932)	(0.04641)
Attendance VA	0.02681**	0.13394**	0.05494**	0.27459**

	(0.00215)	(0.01072)	(0.00316)	(0.01575)
Observations	197639	197639	197639	197639

Note: Columns (1) and (2) report results from a school-cohort fixed effects model. Columns (3) and (4) report results from a Two-Stage Least Squares model by using the average teacher value-added across cohorts within schools as instruments. Standard errors are clustered at both student and teacher level to account for correlation between observations. The columns are estimated using data pooling across 7th-11th grades. All models control for the baseline student, class, and school level characteristics, which include lagged math and English scores, absence rates, suspension, and demographic composition; tests students took in both previous and current year interacted with grade; year fixed effects; and subject fixed effects. Value-added scores are "leave-year-out" estimates standardized using "true" standard deviations of teacher effects estimated using all years of data. ** $p<0.01$, * $p<0.05$, + $p<0.10$.