

Online Appendix

Are Two Teachers Better Than One?

The Effect of Co-Teaching on Students With and Without Disabilities

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Appendices

A Data Appendix

A.1 SIMS Data

The SIMS data comes from information transmitted from school districts to the state of Massachusetts. The data is reported to the state 3 times per year. We used only the information as reported in spring of the relevant academic year. The unit of observation in these data files is the student. After standardizing variable names to be common across years, we merged the files to generate a panel data set at the student-year level. From there, we resolved inconsistencies in the labeling of the data. For example, the gender variable sometimes coded males as “M” and others as “m”; we ensured such coding was common across all years.

A.2 MCAS Data

The state of Massachusetts provided MCAS data for the spring test administration spanning the years 2008 through 2018. After standardizing variable names across years, we merged the files into a panel data set at the student-year level. For the years 2008-2014 and 2017-2018, we use raw MCAS scores and standardize them within year and grade to have mean 0 and σ 1. For the years after 2015, some students in the state took Partnership for Assessment of Readiness for College and Careers (PARCC) test, some took MCAS, and others took both. For these years, we take the raw MCAS scores wherever available. The state was unable to locate raw PARCC scores for this study. For the 2015 test we used PARCC to MCASS concordance scores and for the 2016 test, we used PARCC theta scores.¹¹ Within each of these years, we standardized the test scores at the test-type (raw MCAS, PARCC concordance, PARCC theta) and grade level to have mean 0 and σ 1. In addition, we control for test-type (raw MCAS, PARCC concordance, PARCC theta) in the relevant value-added and school quality specifications. For years 2017 and 2018, we only use the

¹¹These are transformed versions of the raw scores meant to adjust for question difficulty using techniques from item response theory.

MCAS scores.

A.3 EPIMS Data

The EPIMS data comes from information transmitted from school districts to the state of Massachusetts. The unit of observation in this data is a teacher-school-course-section-term. After standardizing variable names, we merged the files into a single data set at the teacher-year-school-course-term level. From there, we resolved inconsistencies in the data. For example, the gender variable sometimes coded males as “M” and others as “m”; we ensured such coding was common across all years.

A.4 SCS Data

The SCS data come from information transmitted from school districts to DESE. Prior to 2011, the state did not collect data on student coursework. The unit of observation in this data is a student-school-course-section-term. After standardizing variable names, we merged the files into a single data set at the student-year-school-course-section-term level. This data came to us with consistent year-to-year coding and required virtually no cleaning after merging. The research assistant working on this project was very excited about this development.

B Additional Tables

Table B1: Percentage of Students in Co-Taught Classrooms by Grade and Year, ELA Sample

	2011	2012	2013	2014	2015	2016	2017	2018	2018-2011
Students With Disabilities									
Grade 3	0.054	0.082	0.076	0.071	0.140	0.087	0.146	0.239	0.185
Grade 4	0.044	0.073	0.077	0.073	0.143	0.104	0.168	0.259	0.215
Grade 5	0.031	0.059	0.075	0.095	0.145	0.115	0.153	0.268	0.238
Grade 6	0.048	0.055	0.101	0.085	0.124	0.113	0.146	0.232	0.184
Grade 7	0.039	0.056	0.083	0.091	0.112	0.109	0.149	0.241	0.202
Grade 8	0.043	0.043	0.092	0.076	0.097	0.106	0.141	0.212	0.169
Students Without Disabilities									
Grade 3	0.044	0.065	0.065	0.057	0.109	0.069	0.132	0.173	0.128
Grade 4	0.036	0.062	0.063	0.052	0.119	0.084	0.146	0.211	0.175
Grade 5	0.024	0.055	0.057	0.079	0.117	0.089	0.129	0.197	0.172
Grade 6	0.029	0.044	0.064	0.054	0.084	0.069	0.095	0.146	0.117
Grade 7	0.023	0.020	0.043	0.050	0.071	0.068	0.089	0.131	0.108
Grade 8	0.014	0.023	0.044	0.045	0.051	0.048	0.065	0.104	0.090

Note: Table reports the percentage of students within Massachusetts taught in a co-taught classroom by grade and year. Top panel reports results for SWDs and the bottom panel reports results for students without disabilities. Final column reports the change in the percentage of students in co-taught classrooms within the respective grade from 2011 through 2018.

Table B2: Percentage Years Observed Co-Taught After First Co-Taught Year

Obs After 1st Co-Taught	Students With Disabilities			Students Without Disabilities		
	Students	Mean Co-Taught	St.Dev. Co-Taught	Observations	Mean Co-Taught	St.Dev. Co-Taught
1	7,785	0.334	0.472	18,654	0.194	0.396
2	5,552	0.238	0.351	13,212	0.127	0.259
3	5,195	0.221	0.276	13,147	0.145	0.225
4	2,921	0.209	0.258	7,500	0.110	0.181
5	1,669	0.179	0.229	4,694	0.115	0.177
6	904	0.166	0.213	2,500	0.067	0.116
7	241	0.165	0.187	632	0.081	0.127

Note: This table describes the percentage of student observations in years following their first co-taught year in which the student is also co-taught. Information is reported separately according to the number of years that the student is observed following their first co-taught year, and by whether or not the student has a disability. “Obs After 1st Co-Taught” reports the number of years that the student is observed following their first co-taught year, such that 1 indicates that the student is observed exactly 1 subsequent year (not necessarily the immediately following year) after the student is first observed in a co-taught classroom. Table includes all students in the estimation sample. Thus, only students who were first observed co-taught in 2011 could have 7 additional observations, and so on. Students could be no longer observed in the data either because they enter a non-tested grade or if they are no longer enrolled in a Massachusetts public school.

Table B3: Descriptive Statistics by Whether School is Observed to have Co-Teaching During Sample Period

	(1)	(2)	(3)	(4)
	School SWD	Co-Teach No SWD	School SWD	No Co-Teach No SWD
Female	0.366	0.527	0.368	0.528
White	0.811	0.794	0.874*	0.846*
Black	0.174	0.138	0.115*	0.097*
Hispanic	0.212	0.166	0.204	0.164
Asian	0.041	0.093	0.035*	0.081
Free Lunch	0.445	0.325	0.400*	0.287*
Reduced Lunch	0.045	0.041	0.042*	0.037
Autism	0.059		0.057	
Communication	0.148		0.148	
Emotional	0.059		0.055	
Health	0.116		0.111	
Neurological	0.049		0.048	
Specific Learning	0.285		0.283	
ELA Score	-0.781	0.215	-0.706*	0.273*
Math Score	-0.752	0.209	-0.680*	0.262*
Classroom Size	20.770	23.287	20.768	22.597*
% Obs Co-Taught	0.107	0.071	0.019*	0.009*
Observations	378186	1280337	315926	1080493

* $p < .05$ Relative to Respective Disability Category

Note: Table reports descriptive characteristics by special education status separately for schools in which we do or do not observed co-teaching during the sample period. Inferential statistics derived from regression controlling for school fixed-effects. Columns 1 and 2 include schools in which we observe at least one co-teaching observation, and Columns 3 and 4 include schools in which we do not observe co-teaching.

Table B4: Percentage of Students in Special Education by Grade and Year, ELA Sample

	2011	2012	2013	2014	2015	2016	2017	2018
Grade 3	0.147	0.148	0.148	0.147	0.153	0.150	0.159	0.169
Grade 4	0.160	0.160	0.158	0.160	0.162	0.164	0.169	0.177
Grade 5	0.153	0.166	0.163	0.167	0.169	0.162	0.177	0.182
Grade 6	0.163	0.166	0.172	0.167	0.171	0.167	0.173	0.182
Grade 7	0.163	0.166	0.168	0.166	0.168	0.168	0.172	0.174
Grade 8	0.167	0.162	0.163	0.163	0.167	0.162	0.170	0.174
G8-G3	0.019	0.014	0.014	0.015	0.014	0.011	0.010	0.005

Note: Table reports the percentage of students within Massachusetts who are in special education (i.e. have an Individual Education Plan) by grade and year. Final row reports the difference in the percentage of students in special education between grade 3 and grade 8 in a respective year.

Table B5: Effect of Co-Teaching by Grade Levels: IEP by Year

	(1)	(2)	(3)	(4)	(5)	(6)
	English Language Arts					
Co-Teaching	0.012** (0.005)	0.013** (0.006)	0.013** (0.006)	0.001 (0.002)	-0.004 (0.003)	-0.001 (0.003)
Co-Teaching × Elementary		-0.003 (0.009)	-0.003 (0.009)		0.009** (0.004)	0.008* (0.004)
Observations	105355	105355	105355	367936	367936	367936
	Mathematics					
Co-Teaching	0.027*** (0.005)	0.036*** (0.005)	0.036*** (0.005)	0.013*** (0.002)	0.015*** (0.003)	0.014*** (0.003)
Co-Teaching × Elementary		-0.024*** (0.009)	-0.023** (0.009)		-0.004 (0.004)	-0.003 (0.004)
Observations	95307	95307	95307	310552	310552	310552
Sample	SWD	SWD	SWD	No SWD	No SWD	No SWD
Student FE	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Class Demographics	No	No	Yes	No	No	Yes
SWD Share	No	No	Yes	No	No	Yes
SWD Share × SWD	No	No	Yes	No	No	Yes

Note: This table presents the effect of co-teaching on standardized ELA and Math scores. “Co-Teaching” takes a value of 1 if a student was in a co-taught classroom in the subject area. Analysis differs from primary regression in that students are defined as having a disability during years that they are in special education rather than being classified as ever having a disability. The sample is restricted to students enrolled in grades three through eight that we observe in a co-taught class in the subject area at least once. “Elementary” takes a value of 1 if a student is below grade six. All regressions also control for an indicator for elementary grades. In columns (1) to (3), the sample is restricted to SWDs. In columns (4) to (6), the sample is restricted to students without disabilities. Standard errors are clustered at the student level and reported in the parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B6: Effect of Co-Teaching by Demographics: SWD Sample

	ELA		Math	
	(1)	(2)	(3)	(4)
Autism	0.021 (0.017)		0.022 (0.016)	
Communication	0.037*** (0.009)		0.017* (0.009)	
Emotional	0.022 (0.017)		0.028* (0.017)	
Health	0.014 (0.011)		0.037*** (0.010)	
Neurological	0.022 (0.017)		0.037** (0.016)	
Specific Learning	0.030*** (0.007)	0.020** (0.009)	0.045*** (0.006)	0.042*** (0.008)
Specific Learning × Elementary		0.001 (0.016)		-0.001 (0.015)
Observations	143351	42585	129668	39025

Note: This table documents the effect of co-teaching for SWDs by special education classifications. The sample is restricted to SWDs enrolled in grades three through eight that we observe in a co-taught class in the subject area at least once. In columns (2) and (4), we further restrict to students with specific learning disabilities and interact the effect of co-teaching with elementary grades. Standard errors are clustered at the student level and reported in the parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B7: Effect of Co-Teaching: by Special Education Classroom

	English Language Arts			Mathematics		
	(1)	(2)	(3)	(4)	(5)	(6)
Co-Teaching	0.008 (0.007)	0.008 (0.007)	0.010* (0.006)	0.034*** (0.006)	0.036*** (0.006)	0.035*** (0.005)
Co-Teaching × Elementary	0.010 (0.011)	0.012 (0.012)	0.006 (0.009)	-0.020* (0.011)	-0.021* (0.011)	-0.014* (0.009)
Sped Class	0.004 (0.007)	-0.002 (0.007)	0.003 (0.005)	0.008 (0.006)	0.007 (0.006)	0.000 (0.005)
Sped Class × Elementary	-0.023** (0.011)	-0.013 (0.011)	-0.006 (0.008)	-0.014 (0.011)	-0.010 (0.011)	-0.009 (0.008)
Observations	83171	80037	122546	74511	71957	111954
r ²	0.763	0.761	0.767	0.772	0.768	0.777
<i>F Test p-values</i>						
Co-Teach + Interaction = 0	0.048	0.038	0.030	0.123	0.123	0.005
Sped Class + Interaction = 0	0.048	0.128	0.700	0.518	0.748	0.176
Sped Class Definition	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
Student FE	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the effect of co-teaching on standardized ELA and Math scores with special education classroom controls. Each column represents models using different ways of identifying special education classrooms. In columns (1) and (4), a special education classroom is identified when the teacher has a job assignment of special education or when the share of IEP students is higher than 80%; In columns (2) and (5), a special education classroom is identified when the teacher has a job assignment of special education and the share of IEP students in the class is higher than 25% or when the share of IEP students is higher than 80%; In columns (3) and (6), a special education classroom is identified when the share of IEP students is higher than 40%. “Co-Teaching” takes a value of 1 if a student was in a co-taught classroom in the subject area. The sample is restricted to students enrolled in grades three through eight that we observe in a co-taught class in the subject area at least once. “Elementary” takes a value of 1 if a student is below grade six. Standard errors are clustered at the student level and reported in the parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B8: Descriptive Statistics for Heterogeneity Analysis, SWD

	(1)	(2)	(3)	(4)	(5)
	Female	Male	White	Black	Hispanic
Female	1.000	0.000	0.369	0.365	0.383
White	0.795	0.791	1.000	0.158	0.817
Black	0.195	0.198	0.039	1.000	0.183
Hispanic	0.227	0.213	0.225	0.203	1.000
Asian	0.036	0.038	0.008	0.008	0.010
Free Lunch	0.497	0.470	0.423	0.726	0.763
Reduced Lunch	0.046	0.050	0.048	0.045	0.044
Autism	0.022	0.073	0.057	0.038	0.032
Communication	0.155	0.151	0.144	0.157	0.180
Emotional	0.048	0.060	0.052	0.078	0.066
Health	0.090	0.141	0.132	0.096	0.106
Neurological	0.056	0.049	0.054	0.043	0.043
Specific Learning	0.356	0.275	0.306	0.319	0.311
ELA Score	-0.801	-0.917	-0.818	-1.125	-1.159
Math Score	-0.952	-0.781	-0.791	-1.121	-1.099
Classroom Size	21.730	21.475	21.515	21.884	21.677
% Obs Co-Taught	0.251	0.252	0.251	0.260	0.251

Standard errors in parentheses

Note: This table reports sample characteristics for regressions reported in Table 5. Table compares observed characteristics for observations within schools that we observe offering co-teaching at any time (“School With Co-Teach”) or that we do not observe with any co-teaching (“School Without Co-Teach”). Test for inference compares Column 1 vs Column 3 and Column 2 vs Column 4. Race/ethnicity classifications are not mutually exclusive in the data.

Table B9: Descriptive Statistics for Heterogeneity Analysis, No SWD

	(1)	(2)	(3)	(4)	(5)
	Female	Male	White	Black	Hispanic
Female	1.000	0.000	0.520	0.533	0.534
White	0.768	0.773	1.000	0.154	0.808
Black	0.179	0.170	0.035	1.000	0.188
Hispanic	0.196	0.186	0.200	0.206	1.000
Asian	0.080	0.082	0.014	0.011	0.013
Free Lunch	0.391	0.376	0.318	0.674	0.718
Reduced Lunch	0.044	0.045	0.041	0.054	0.051
ELA Score	0.211	-0.040	0.153	-0.273	-0.310
Math Score	0.059	0.089	0.128	-0.355	-0.329
Classroom Size	23.910	23.869	23.665	24.927	24.432
% Obs Co-Taught	0.237	0.234	0.232	0.261	0.258

Standard errors in parentheses

Note: This table reports sample characteristics for regressions reported in Table 4. Table compares observed characteristics for observations within schools that we observe offering co-teaching at any time (“School With Co-Teach”) or that we do not observe with any co-teaching (“School Without Co-Teach”). Test for inference compares Column 1 vs Column 3 and Column 2 vs Column 4. Race/ethnicity classifications are not mutually exclusive in the data.

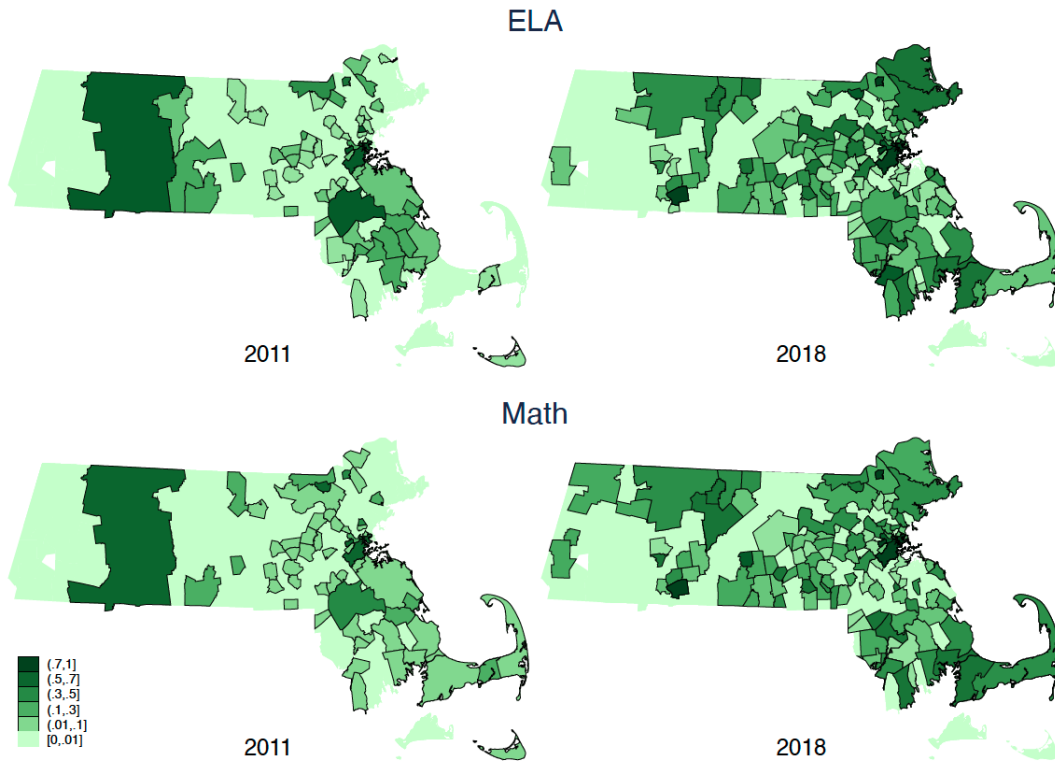
Table B10: Effect of Co-Teaching: Student Fixed Effect and Lagged Dependent Variable

	Standardized Test Scores					
	(1)	(2)	(3)	(4)	(5)	(6)
<i>English Language Arts</i>						
Co-Teaching	0.013*** (0.005)	-0.005 (0.006)	-0.009 (0.007)	-0.006** (0.003)	-0.008** (0.004)	-0.018*** (0.004)
Co-Teaching × Elementary	0.004 (0.008)	0.026*** (0.010)	0.033** (0.014)	0.010** (0.004)	0.011** (0.006)	0.038*** (0.008)
Observations	143351	108204	76582	340656	256711	177380
r ²	0.778	0.546	0.482	0.807	0.589	0.542
<i>F Test p-values</i>						
Co-Teach + Interaction = 0	0.004	0.007	0.050	0.236	0.504	0.005
<i>Mathematics</i>						
Co-Teaching	0.035*** (0.005)	0.014*** (0.005)	0.010 (0.006)	0.013*** (0.003)	-0.006* (0.003)	-0.013*** (0.004)
Co-Teaching × Elementary	-0.022*** (0.008)	0.010 (0.010)	0.009 (0.014)	-0.003 (0.004)	0.016*** (0.006)	0.029*** (0.008)
Observations	129668	97903	70175	285687	215431	150656
r ²	0.793	0.576	0.508	0.845	0.672	0.615
<i>F Test p-values</i>						
Co-Teach + Interaction = 0	0.037	0.004	0.141	0.001	0.030	0.036
Sample	SWD	SWD	SWD	No SWD	No SWD	No SWD
Student FE	Yes	No	No	Yes	No	No
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Prior Year Score	No	Yes	No	No	Yes	No
Two Year Prior	No	No	Yes	No	No	Yes

Note: This table reports the specification test results. In columns (1) and (4), the student fixed effects model is used. In columns (2) and (5), the model with controls for observed student demographics and a lagged dependent variable is used. In columns (3) and (6), the model with controls for observed student demographics and a two-year-lagged dependent variable is used. “Co-Teaching” takes a value of 1 if a student was in a co-taught classroom in the subject area. The sample is restricted to students enrolled in grades three through eight that we observe in a co-taught class in the subject area at least once. “Elementary” takes a value of 1 if a student is below grade six. In columns (1) to (3), the sample is restricted to SWDs. In columns (4) to (6), the sample is restricted to students without disabilities. Standard errors are clustered at the student level and reported in the parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

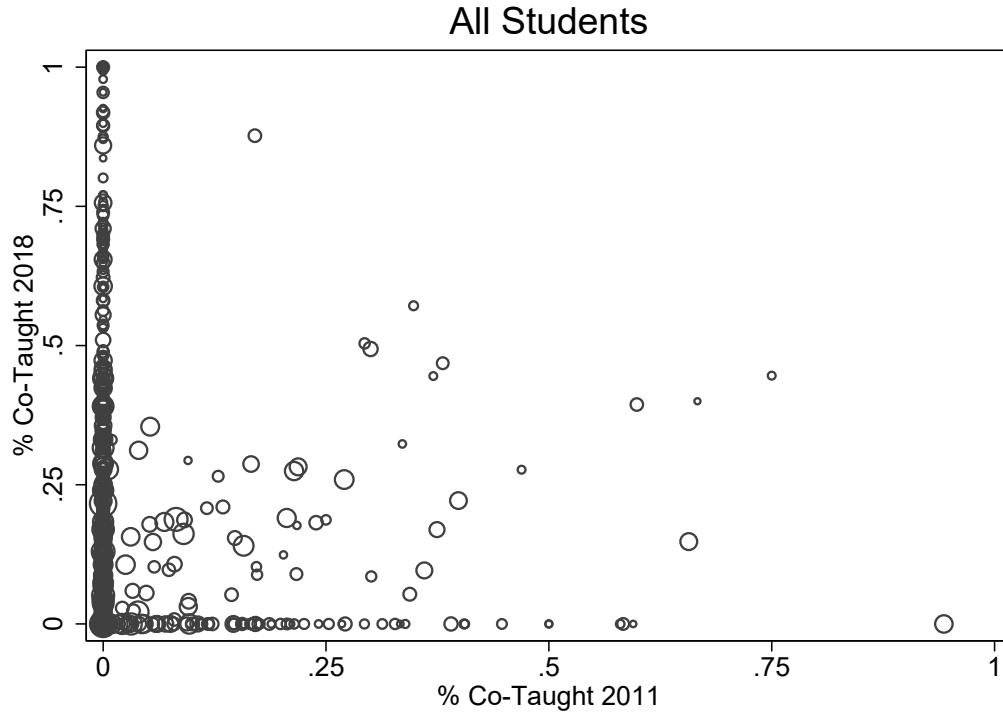
C Additional Figures

Figure C1: Change in the Share of Co-Taught Students by Massachusetts School Districts



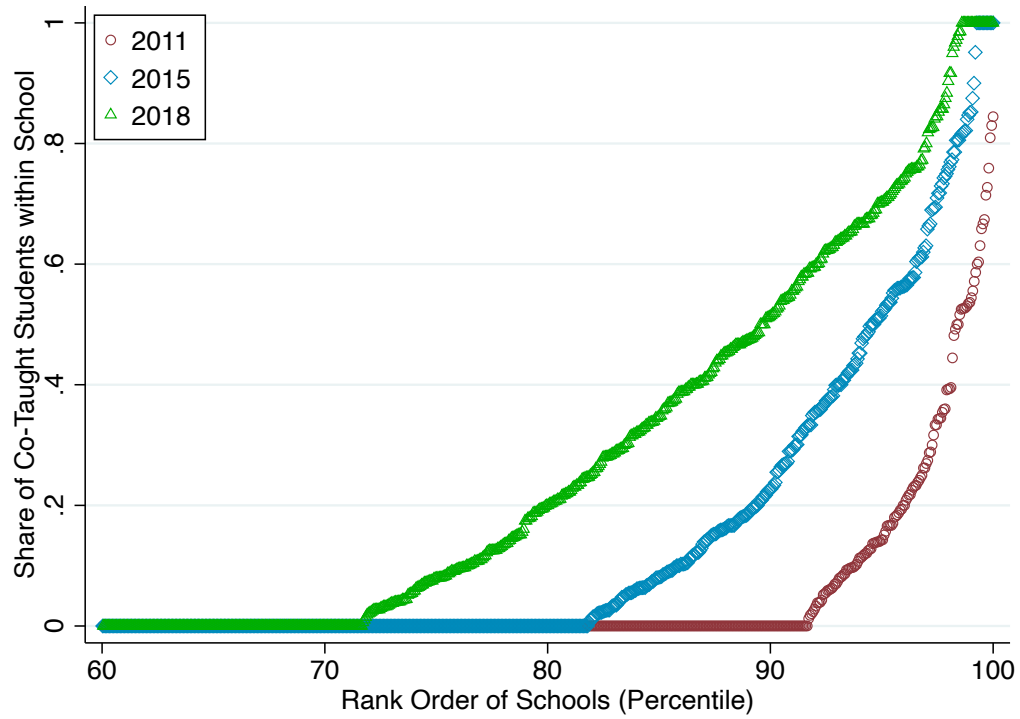
Note: This figure displays the share of co-taught students in 2011 and 2018 by Massachusetts school districts in the ELA and math samples we used to estimate the effect of co-teaching. The school districts with the darkest color have more than 70% of the students co-taught in the subject.

Figure C2: Share of Co-Taught SWDs within Schools: ELA Sample



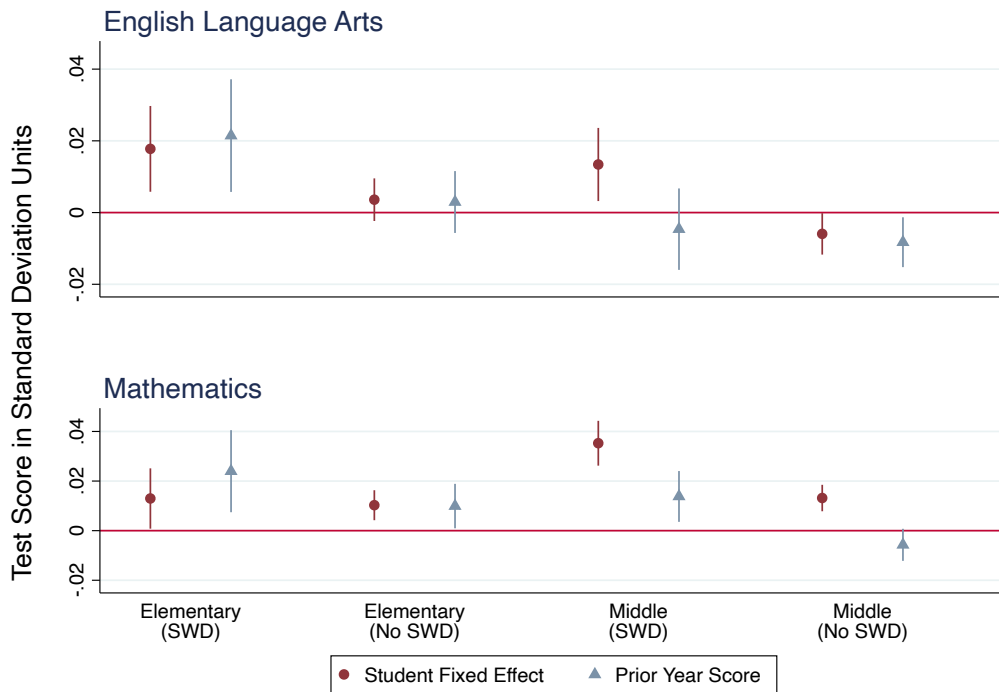
Note: This figure plots the percentage of all students in a co-taught classroom by school during the 2011 and 2018 school years. Each circle on the figure is a school in a given year. Size of circle illustrates total enrollment within the school in grades 3 through 8. The vertical axis is the percentage of students within the school that year who are in a co-taught classroom, and the horizontal axis simply ranks the schools according to their proportion of co-taught students in order to achieve a sloping line.

Figure C3: Share of Co-Taught SWDs within Schools: ELA Sample



Note: This figure plots the share of co-taught students within each school in the ELA sample. The circles, diamonds, and triangles represent the share of co-taught students in each school in the years 2011, 2015, and 2018, respectively. The x-axis plots the percentiles of the within-year distribution of the share of co-taught students.

Figure C4: Effect of Co-Teaching: Student Fixed Effect and Lagged Dependent Variable



Note: This figure illustrates the specification test results. Circles are the estimated effects of co-teaching from the student fixed effects model. Triangles are the estimated effects of co-teaching from the model with controls for observed student demographics and a lagged dependent variable. “Elementary” indicates grades from three through five. “Middle” indicates grades from six through eight. Vertical bars represent 95% confidence intervals. For the numerical values underlying this figure, see Table B10.