Supplementary Online Materials
For

Parent Engagement Interventions are Not Costless: Opportunity Cost and Crowd Out of Parental Investment

Contents

Additional Sample Details

The experiment took place in five secondary schools in England during the 2013-14 school year. Three of the schools were in London and the other two were within 50 miles. The schools were recruited by a non-profit organization that had established a network of schools committed to developing evidence-based innovations in education. Schools that were within easy traveling distance of the research team were prioritized and no other filtering criteria were used.[1] Descriptive statistics for the five schools are presented in Table S1.

Table S1. Descriptive statistics for sample schools

School	N stud	% 5 A*- C	% FRPL	% ESL	Gender	Academy	Ofsted
A	858	77	38	51	Mixed	Yes	Outstanding
B	1488	70	12	11	Mixed	No	Good
C	859	71	20	81	Mixed	Yes	Outstanding
D	1135	63	13	10	Mixed	No	Good
E	738	72	5	1	Mixed	No	Good
Sample avg.	1016	71	18	31			
England avg.	824	59	16	14			

Schools in London and the South-East tend to perform better than the national average and recent research has attributed at least part of this differential to the higher proportion of immigrant children in these schools (Burgess, 2016). The schools in the sample do indeed have a higher proportion of students for whom English is not the first language at home (English as a Second Language; ESL, 31% v 14%) and perform better than the national average, as illustrated by the percentage of students that achieved 5 A*-C grades at GCSE in 2013, the metric most commonly used for judging school performance at the time of the experiment.[2]

The schools have a marginally higher than average proportion of students who receive free school meals (18% v 16%). Students are eligible for free school meals (FRPL) if they are economically disadvantaged and this group are half as likely to achieve five A*-C grades at GCSE than non-FRPL students (Cassen et al., 2015). Two of the schools are 'academies', which means they are free from local government control. Approximately 60% of secondary schools in England are academies, so again the sample is roughly representative in these terms. We did not receive individual data on students' race/ethnicity, language, or gender.

Withdrawals & Exclusions

All students' parents received a letter informing them that a study was to take place in which they might be randomly chosen to receive additional information regarding their child's schooling. Students were excluded from the experiment for any of the following reasons; their parents requested they be withdrawn from the study (n = 116); the school had no working mobile

[1] The research team consisted of a team of five research assistants, one for each school

[2] GCSEs are standardized tests sat by all 16-year-olds in England. A student typically sits up to 9 GCSEs in a range of subjects (Math, English and Science are compulsory), after which point a student may choose up to 4 A-Levels which universities use for judging applications. The 5 A*-C was the primary metric used to rank schools on national league tables at the time of the experiment.

phone number for any parent (n = 146); or students were not tested during the window during which the researchers were available to run the experiments or they were enrolled into the Business and Technology Education Council (BTEC) program (n = 1,353; BTEC is equivalent to a vocational program). These students did not participate in the intervention and their data was excluded from subsequent analyses. The school-by-school breakdown of parent opt-outs and exclusions because of missing parent contact details are shown in Table S2. The remaining 3,483 students participated in the experiment and their distribution across schools and year groups is also shown in Table S2. As indicated above, most of the exclusions were because that year group had no test in the implementation window, or because they were Grade 10 or Grade 11 students enrolled for the BTEC qualification.

Table S2. Distribution of experimental population across schools and grades

	Removed		Remaining						
School	Parent Opt-out	No Mobile Number	G7	G8	G9	G10	G11	Total	%
A	16	19	164	157	167	118	126	732	89%
B	18	32	256	0	262	237	0	755	52%
C	0	56	174	0	130	111	112	527	80%
D	51	19	185	195	212	134	139	865	91%
E	31	20	114	125	127	108	110	584	85%
Total	116	146	893	477	898	708	487	3,463	76%

Balance Randomization

After withdrawals and exclusions as per the criteria stated above, we randomly assigned 1,754 students to the control group and 1,729 to the treatment group. The randomization was stratified by class, prior attainment (captured by within-school and grade standardized scores on their most recent low-stakes science test), and FRPL status. Table S3 shows no statistically significant differences between treatment and control groups for these covariates.

Table S3. Balance Table

	Mean (SD)		p-value
	Control	Treatment	p(C = T)
Student Characteristic			
Prior Attainment	0.042	0.054	0.589
	(0.973)	(0.969)	
FRPL	0.243	0.231	0.401
	(0.421)	(0 .414)	

More Details on the Study Design & Procedure

In advance of the first conversation prompt, the research team texted treatment group parents an explanation of the conversation prompts that would follow, along with a note that they

need not reply. Many parents still did reply with the answer to the question or other comments. These replies were monitored by a research assistant in case they warranted a response.

The prompts were written by teachers and occasionally edited by research assistants to fit the texting software's character limit or to make the language more accessible to parents. Teachers were encouraged to use a common structure of first describing what was taught in a non-technical manner and then posing a question that might stimulate genuine curiosity in the parent. See Appendix S2 for a sample of the conversation prompts sent by teachers.

Parents would be sent a maximum of one text per day and if two science lessons were taught on the same day, conversation prompts were alternated a weekly basis. Table S6 shows the variation in texts per week across and within the partner schools. Some teachers and schools were harder to engage in the intervention than others and considerable effort and time was required of the research team to ensure the intervention could be delivered as consistently as it was. Parents of 10th and 11th graders (the oldest in the experiment) were texted 0.3 times per week more than other year groups, a difference of 15%. As far as we are aware, neither treatment group nor control group parents received additional information about curriculum content via text messages or email during the time the intervention was taking place.

At the end of the experiment and after the test used as the outcome measure, both treatment and control group students completed a short survey in class. Teachers were not able to see the responses as students were instructed to place their responses into an envelope which was then sealed and returned to a research assistant. Surveys were completed after the test, but before students had received their grade. The full survey and additional results can be found in Appendix S1 and Table S7. The study preregistration can be found at: https://www.socialscienceregistry.org/trials/349.

Data

Baseline data included students' grades on their most recent science test and their FRPL eligibility. Grading systems are idiosyncratic to the school as students are not assessed on a standardized scale until they take their GCSEs at age 16. Students within the same grade of the same school often have their attainment coded on a common scale, while often taking different tests (although they all generally follow the same curriculum). In some schools, students may be allocated to science classes according to their ability and so their tests will often have a different range of available grades, with some overlap. For example, the bottom set might sit a test with a grade range of B – E (B – F, in the US), while the top set might take a test with a range of A* – C (A^+ – B, in the US). Even though students are sitting different tests within the same year group, schools consider their grades to be comparable within a grade. However, neither the test in this experiment nor the measure of prior attainment can be considered to measure ability as accurately as the standardized tests students take at the end of 11th grade (GCSEs), or perhaps even those taken in 6th grade, their last year of primary school (SATs).

The typical science classes are: Biology, Chemistry and Physics. While the majority of students only took once science class at a time, students could also take multiple science classes at a time. Therefore, students may have participated in the intervention in multiple science classes.[3] Moreover, schools' grading practices varied considerably. In some cases, grades were

[3] In the UK, only students in grades 10 and 11 may take more than one science class (which comprise 34.5% of our sample). Nationally, 24% of students in 10th and 11th grade take multiple science classes (i.e., they take some combination of physics, chemistry, and biology. We can therefore estimate approximately 8% of our sample may

merged into a single measure of attainment while others gave us separate grades for Biology, Chemistry and Physics. These differences were not always accounted for by the grade the student was in or the number of classes they were taking. To proceed, we decided to merge all science grades into a single average science grade, and then standardized these single measures of attainment to have mean zero and a standard deviation of one. We used the same approach for the test grades outcomes data.

Additional Analyses

Science Test Scores

Table S4 shows the results for experiment. Column 1 shows the effect on test scores, in within-grade standard deviations, with no covariates. The treatment effect is 0.036-*sd*. Column 2 adds class level fixed effects. Prior attainment and FRPL status are added as covariates in column 3. Columns 4-6 in Table S4 provide details on the heterogeneity analyses by FRPL status, prior attainment tercile, and texts/week (dosage), respectively.

Table S4. Treatment Impact on Test Grades

	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.036	0.037	0.027	0.037		0.088*
	(0.033)	(0.024)	(0.021)	(0.023)		(0.052)
Treatment *FRPL				-0.044		
				(0.052)		
Treatment *Low					0.003	
					(0.040)	
Treatment *Medium					0.024	
					(0.037)	
Treatment *High					0.054*	
					(0.032)	
Treatment *Texts/Wk						-0.030
						(0.024)
Class FE	No	Yes	Yes	Yes	Yes	Yes
Student Covariates	No	No	Yes	Yes	Yes	Yes
n	3483	3483	3483	3483	3483	3483
R^2	0.000	0.510	0.630	0.630	0.630	0.630

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors (in parentheses) clustered at the class level.
Notes: Units are science test grades in within-grade standard deviations.
Treatment*FRPL is treatment status multiplied by a dummy variable for FRPL status.
Treatment*Low, Treatment*Medium and Treatment*High are treatment status multiplied by a dummy variable for each ability tercile (by prior attainment).
Treatment*Texts/week is treatment status multiplied by the number of texts sent per week by the science teacher.

have been enrolled in multiple science classes. These are typically the higher attaining students, on track to study science at A level or at university.

We also explored whether the treatment effect varied by grade and found nothing notable, as shown in Table S5. Table S6 shows variation in treatment effects by school. The only statistically significant treatment effect (only at the 10% level) was found in School E. The school with the largest treatment effect also had the fewest students recorded as ESL.

Table S5. Treatment effect by grade level on science tests

	(1) G7	(2) G8	(3) G9	(4) G10	(5) G11
Treatment	0.024	0.043	-0.004	0.055	0.0489
	(0.046)	(0.066)	(0.034)	(0.051)	(0.050)
n	893	477	898	708	487
R^2	0.596	0.571	0.729	0.633	0.608

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors (in parentheses) clustered at the class level.
Units are science test grades in within-grade standard deviations and FRPL and prior attainment as covariates.

Table S6. Treatment effects by school on science tests

School	A	B	C	D	E
Mean texts/week	2.32	2.76	1.94	1.04	1.93
SD texts/week	0.68	0.64	0.68	0.44	0.91
Treatment effect	0.024	0.014	0.023	0.011	0.073*
	(0.050)	(0.050)	(0.059)	(0.039)	(0.038)
n	732	755	547	865	584
R^2	0.703	0.626	0.540	0.694	0.549

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors (in parentheses) clustered at the class level.
Units are science test grades in within-grade standard deviations and FRPL and prior attainment as covariates.

Student Survey

All the items on the student survey are listed in Appendix S1. Below, we provide some additional details on the items and how they are being used in the analysis.

Question 2: Parental Behaviors.

The response items marked with [a] are being used in the Parenting Behavior Index to assess whether the intervention crowded out other parenting behaviors. The response item marked with [b] is not included in the Parenting Behavior Index because it is indicating a lack of behavior. The response item marked with [c] is not included in the Parenting Behavior Index because it directly relates to the treatment (i.e., the intervention should have increased the likelihood parents tested their child on what they learned in science class).

Question 3: Parent-Child Discussion Topics.

The response items marked with [d] are being used in the Parent-Child Discussion Topic Index to assess whether the intervention crowded out other parent-child discussions. The response item marked with [e] is not included in the Parent-Child Discussion Topic Index because it is indicating a lack of discussion. The response item marked with [f] is not included in the Parent-Child Discussion Topic Index because it directly relates to the treatment (i.e., the

intervention should have increased the likelihood parents talked to their child about what they were learning about in science class).

All Survey Items

Table S7 shows the treatment impact on each of the individual items that are not detailed in Table 1 of the manuscript.

Table S7. Student survey items (control baselines and treatment effects)

Survey #	Outcome	Control Mean	Treatment Effect	*p*-value	*n*	R^2
6	Science convos/week	1.27	0.273***	.000	2173	0.134
			(0.059)			
7	More science convos v normal/less	10.7%	0.062***	.000	2036	0.101
			(0.011)			
8	More other convos v normal/less	11.4%	-0.016	.136	2136	0.091
			(0.023)			
1	Want convo prompts	34.0%	0.073***	.000	2193	0.133
			(0.022)			
4	Parents will ask grade	75.0%	-0.023	.232	2194	0.100
			(0.019)			
5	Do better when parents ask	39.0%	0.024	.265	2143	0.133
			(0.022)			
12	Would enjoy convo prompts	31.8%	0.058***	.007	2096	0.136
			(0.021)			
13	Personal desire to learn	89.0%	0.002	.919	2128	0.105
			(0.015)			
14	Do well to please parents	72.7%	0.005	.784	2118	0.099
			(0.018)			
11	Did better on recent test vs. same/worse	23.1%	-0.012	.398	2153	0.154
			(0.014)			
15	Want to study sci level A	48.0%	-0.059*	.068	434	0.268
			(0.031)			
16	Want to study science at university	36.0%	-0.021	.463	433	0.218
			(0.029)			
9	Own parents texted	10.5%	0.732***	.000	2120	0.591
			(0.019)			
10	Classmates parents texted	28.6%	0.175***	.000	2120	

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Standard errors (in parentheses) clustered at the class level.

Units are science test grades in within-grade standard deviations and FRPL and prior attainment as covariates.

The observations range from 433 to 2,194 because groups of students took several different versions of the survey and questions were added during the survey implementation period. Minor differences in the number of observations between the same versions exist because research assistants manually entered the paper survey responses and if a student did not respond to a certain item it was coded as missing.

Question 10 reports the tabulated information (not the regression results).

Tables S8 and S9 tabulate the responses for two of the key items (6 and 7) by condition. Finally, Table S10 breaks down the treatment effect of item 6 and the Parenting Behavior Index by school. The treatment effect on student reported parental engagement does not appear to associate with students' science test scores by school (see Table S6).

Table S8. Tabulation of Response Options for Question 6, "In the past month, how often did your parent(s)/carer(s) talk with you about science class?"

Response Option	Control	Treatment	Total
They did not ask me about science class at all	263 (24.0%)	150 (14.0%)	413 (19.0%)
Less than once a week	247 (22.5%)	214 (19.9%)	461 (21.2%)
Once a week	238 (21.7%)	287 (26.7%)	525 (24.2%)
Twice a week	171 (15.6%)	193 (18.0%)	364 (16.8%)
Three times a week	102 (9.3%)	136 (12.7%)	238 (11.0%)
Four times a week	30 (2.7%)	48 (4.5%)	78 (3.6%)
Five times a week	16 (1.5%)	20 (1.9%)	36 (1.7%)
More than five times a week	31 (2.8%)	27 (2.5%)	58 (2.7%)
Total	1098	1075	2173

Table S9. Tabulation of Response Options for Question 7, "How does this [talking about science class] compare to usual?"

Response Option	Control	Treatment	Total
I spoke about science class more than usual	145 (14.2%)	125 (12.3%)	270 (13.3%)
I spoke about science class the same as usual	686 (67.4%)	598 (58.7%)	1284 (63.1%)
I spoke about science class less than usual	187 (18.4%)	295 (29.0%)	482 (23.7%)
Total	1018	1018	2036

Table S10. Treatment effects by school

School	A	B	C	D	E
Science convos/week	0.150	0.301***	0.127	0.509***	0.317
	(0.126)	(0.10)	(0.151)	(0.115)	(0.238)
Parenting Behavior Index	-.096	-.289***	-.424***	-0.149	-0.318
	(.109)	(0.010)	(.146)	(0.157)	(0.177)
n	521-532	659-669	383-389	410-414	200-203

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Standard errors (in parentheses) clustered at the class level.
Units are science test grades in within-grade standard deviations and FRPL and prior attainment as covariates.

Appendix S1. Student Survey.

Note on survey coding: The coding for each item is in parentheses below, but was not visible to respondents. For "tick all that apply" items, each item was coded with a "1" if it was ticked or a "0" if was not ticked.

Directions: Tick the box next to your answer. There are **25** questions in total and the survey should take less than 10 minutes to complete. Thank you.

1. **Next term, would you like your parent(s)/carer(s) to receive text messages about what you are learning in science class so they can talk with you about it?**

   - ☐ Yes (1)
   - ☐ No (0)

2. **In the last month, to help you prepare for school, has a parent/carer done any of the following?** *(Tick all that apply)*

   - ☐ Tested you on what you have learnt [c]
   - ☐ Turned off the TV, computer, and/or video games [a]
   - ☐ Made you go to sleep at a reasonable hour [a]
   - ☐ Made sure you had a quiet place to study [a]
   - ☐ Checked that you were studying [a]
   - ☐ Something else not listed here [a]
   - ☐ My parent did not do any of these things [b]

3. **In the last month, has a parent/carer discussed any of the following with you when talking about your school experience?** *(Tick all that apply)*

   - ☐ Attendance [d]
   - ☐ Behaviour in class [d]
   - ☐ Participation in class [d]
   - ☐ What you are learning about in class [f]
   - ☐ Focus [d]
   - ☐ Effort [d]
   - ☐ Your current homework/assignments [d]
   - ☐ Catching up with missing homework/assignments [d]
   - ☐ Studying for tests [d]
   - ☐ Grades [d]
   - ☐ Your overall performance [d]
   - ☐ They did not ask me about school [e]

4. **Do you expect a parent/carer to ask you about the grade you got on your recent science test?**

   - ☐ Yes (1)
   - ☐ No (0)

5. **Do you think you do better in science class when your parents know what you are learning about and can talk to you about it?**

- Yes (1)
- No (0)

6. **In the past month, how often did your parent(s)/carer(s) talk with you about science class?**

   - They did not ask me about science class at all (0)
   - Less than once a week (0.5)
   - Once a week (1)
   - Twice a week (2)
   - Three times a week (3)
   - Four times a week (4)
   - Five times a week (5)
   - More than five times a week (6)

7. **How does this compare to usual?**

   a. I spoke about science class more than usual (1)
   b. I spoke about science class the same as usual (0)
   c. I spoke about science class less than usual (0)

8. **In the past month, how often did your parent(s)/carer(s) talk with you about other classes (not science class)?**

   - Less than usual (0)
   - The same as usual (0)
   - More than usual (1)

9. **In the past month, have your parent(s)/carer(s) received text messages about what you have been learning in science class?**

   - Yes (1)
   - No (0)

10. **In the past month, have <u>any of your classmates'</u> parent(s)/carer(s) received text messages about what you have been learning in science class?**

    - Yes (1)
    - No (0)
    - I don't know (0)

11. **How do you think you did on your recent science test?**

    - Better than usual (1)
    - The same as usual (0)
    - Worse than usual (0)

12. **Next term, would you *enjoy* it if your parent(s)/carer(s) received text messages about what you learned in science class so they could talk with you about it?**

    - Yes (1)
    - No (0)

13. **I try to do well in science class because of my own personal desire to learn.**

- True (1)
- False (0)

14. I try to do well in science class because I want to please my parent(s)/carer(s).

- True (1)
- False (0)

15. Do you want to study Level A science?

- Yes (1)
- No (0)

16. Do you want to study science at university?

- Yes (1)
- No (0)

Appendix S2. Selection of Conversation Prompts

School	Text
A	Hi [parent name], today [student name] answered questions about respiration. Please ask them why organisms need to respire. Have a good evening, Mr Henderson
A	Hi [Parents name], Today [students name] revised sound & light waves. Why not ask them the difference between the sound waves produced by a cello and a violin. Regards Dr T
A	Hi [parent name], today [student name] answered questions about animals and plant cells in science today, please ask them to explain the difference between an animal and a plant cell. Have a good evening Mr Hayward.
A	Dear (parent name) Please ask (student name) how their assessment went this afternoon. They should also be able to tell you the rules for drawing graphs in Science lessons. Many thanks, Mr Lawrence
B	Today in Science [Name] learnt about infrasound. Ask [Name] to explain what it is and 3 reasons why it is useful. Ms Blann
B	Today in Science [Name] learnt about using different telescopes. Why not ask them why I put some telescopes in space? Mr Hett
B	Recently I have been working on enzymes. Ask [name] in what foods I eat enzymes. Mr Holter
B	Today [Name] learnt about radiation. Please ask [Name] why heat from the Sun cannot reach Earth by conduction or convection. Mr McLaren
C	Hi <RecipientSalutation>. Your child's year 8 class has been learning about rusting. Please ask your child to explain when and where rusting is a problem (Bikes left out in the rain, bridges spanning bodies of water, boats in seawater, etc.). Thank you Mrs Patel
C	Hi <RecipientSalutation>. Your child's year 8 class has been revising chemical reactions. Please ask them how you can tell which of 2 metals is most reactive. Thanks, Mr F.
C	Hi <RecipientSalutation>. Your child's year 11 class has been learning about alloys. An alloy is a mixture of metals. Please ask why an alloy is stronger than the pure metal it is made from. Thanks, Dr. Patel.
C	Hi <RecipientSalutation>. Your child's year 9 class has been learning about how plants can respond to their environment. Please ask them how they do it, and if they can think of any examples of where plants respond very quickly? Thanks, Mr Silver.
D	Hi [parent]. Today [student name) continued with the animal testing debate. Please ask your child whether they think animal testing should be banned. Miss Patel.
D	Hi [parent]. Today [student name) learned about volcanoes. Please ask your child how igneous rock is formed. Mr Griffith.
D	Hi [parent]. Today [student name) learned about the skeleton. Please ask your child what the skeleton is needed for? Mr Griffith.
D	Hi [parent]. Today [student name) has been learning about the formation of a star. Please ask your child how a small and large star develops. Ms. Sexton.
E	Hi [GUARDIANTITLE] [GUARDIANSNAME]. Today [STUDENTFNAME] learnt about blood pressure. Please ask them what a normal blood pressure is expected to be. Thanks.

E	Hi [GUARDIANTITLE] [GUARDIANSNAME]. Today [STUDENTFNAME] has been learning about gaseous exchange in the alveoli. Please ask them to explain 4 ways the alveoli are adapted for gaseous exchange. Thanks, (school name)
E	Hi [GUARDIANTITLE] [GUARDIANSNAME]. Today [STUDENTFNAME] started a new topic on cells. Please ask them the major differences between plant and animal cells. Thanks, (school name)
E	Hi [GUARDIANTITLE] [GUARDIANSNAME]. Today [STUDENTFNAME] learnt the cross section of a leaf. Please ask them why the top of a leaf is usually darker than the bottom. Thanks, (school name)

References

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Cassen, R., McNally, S., & Vignoles, A. (2015). *Making a difference in education: What the evidence says*. Routledge.