The Effect of Teacher-Family Communication on Student Engagement: Evidence from a Randomized Field Experiment

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Abstract

In this study, we evaluate the efficacy of teacher communication with parents and students as a means of increasing student engagement. We estimate the causal effect of teacher communication by conducting a randomized field experiment in which 6th and 9th grade students were assigned to receive a daily phone call home and a text/written message during a mandatory summer school program. We find that frequent teacher-family communication immediately increased student engagement as measured by homework completion rates, on-task behavior, and class participation. On average, teacher-family communication increased the odds that students completed their homework by 40%, decreased instances in which teachers had to redirect students' attention to the task at hand by 25%, and increased class participation rates by 15%. Drawing upon surveys and interviews with participating teachers and students, we identify three primary mechanisms through which communication likely affected engagement: stronger teacher-student relationships, expanded parental involvement, and increased student motivation.

We are grateful for the financial support provided by EdLabs and the Institute for Quantitative Social Sciences at Harvard University. The idea for this experiment was originally conceived by Michael Goldstein of MATCH Teacher Residency, and is the first research partnership between MATCH Teacher Residency and EdLabs. The methodology was reviewed and approved by the Harvard Committee on the Use of Human Subjects in Research. The authors would like to thank Michael Goldstein, Orin Gutlerner, Erica Winston, Laura Schwedes, Brittany Estes, Veronica Gentile and the staff and teacher residents of Match Charter Public Schools for their continued support throughout this study. We are also indebted to Richard Murnane, Heather Hill, John Willett, Lindsay Page, and Angela Boatman for their invaluable advice and helpful feedback on earlier drafts. All errors and omissions are the authors' own.

Increased communication improved student engagement in class. I was able to look students in the eye at class and remind them of what I spoke to them about the previous evening on the phone, or spoke to their parents about on the phone. The students knew that I noticed everything and that I was going to hold them accountable for their actions. I found students more eager to appear vulnerable in class, less reticent, and more compliant to rules and procedures. I saw students improve on noted weaknesses quickly.

– 9th grade non-fiction MATCH summer academy teacher

Two well-documented findings in educational research, that teachers profoundly affect student achievement (Rivkin, Hanushek, & Kain, 2005; Nye, Konstantopoulus, & Hedges, 2004) and that some teachers are far more effective than others (Sanders & Rivers, 1996; Gordon, Kane, & Staiger, 2006), have dramatically shaped education policy in the past decade. While we know that teachers matter, we still know very little about what practices distinguish great teachers from their less successful peers. Furthermore, only a small fraction of the existing literature on effective instructional practices support causal conclusions that these practices improve student behavior, engagement, or achievement. For example, a review of the Institute for Educational Sciences' What Works Clearinghouse (WWC) reveals that only 4% of the studies they reviewed on student behavior interventions (11 out of 269) met their evidence standard for causal research (see also Yoon et al., 2007 and Murnane & Willett, 2011 p.61).

We sought to begin filling this gap by asking the question - what can teachers do to make students more engaged in their schooling? A large body of literature finds that a high level of student engagement is the cornerstone of effective classroom instruction (e.g. Wang & Holcombe, 2010). Descriptive research (Connell & Wellborn, 1991) and anecdotal evidence (Mahler, 2011) suggest that the nature of relationships between teachers, students, and their parents play an important role in determining a child's level of engagement with school. In this paper, we investigate whether teacher communication with parents and students increases student engagement. Studying teacher-family communication is attractive because it is a low-cost and

potentially underutilized teaching practice. Findings from the 2007 National Household Education Surveys Program show that less than half of all families with school-age children report receiving a phone call from their child's school, and only 54% report getting a note or email about their children (Herrold et. al., 2008). If communicating with parents and students is an effective method of stimulating higher levels of academic engagement, far more teachers and students could be benefitting from this practice.

We evaluate the efficacy of teacher-family communication by partnering with a charter school in Boston, Massachusetts to conduct a cluster-randomized trial during a mandatory summer school academy. This work makes two important contributions to the literature. We present some of the first causal evidence of the effect of personal communication between teachers and parents, and teachers and students, on student engagement in U.S. public schools. Secondly, we capture fine-grained measures of student engagement in the classroom by conducting classroom observations of well-defined, quantifiable student behaviors. These data provide a unique opportunity to examine how teacher-family communication affects students' behavior and participation in the classroom.

In what follows, we present evidence of the importance of student engagement and the link between engagement and teacher-family communication. We then describe our research site and experimental design. We outline the multiple sources of data we draw upon and the methods we use to analyze these data. We then present our findings and discuss three potential mechanisms behind our results that emerge from surveys and interviews with teachers and students in the study. Lastly, we conclude by discussing the implications of our findings for future studies of teacher-communication.

II. Student Motivation and Engagement in the Literature

Our overall theory of change views student engagement as an important mediator of academic achievement, with teachers and parents as the principal actors influencing both students' intrinsic and extrinsic motivation as well as their engagement. A large body of research has documented the strong positive relationship between student engagement and learning outcomes (Connell, Spencer, & Aber, 1994; Connell & Wellborn, 1991; Deci, Vallerand, Pelletier, & Ryan, 1992; Finn & Rock, 2007; Klem & Connell, 2004; Marks, 2000; Skinner, Wellborn, & Connell, 1990). Existing literature also suggests that students' intrinsic and extrinsic motivation, along with their sense of efficacy, are malleable and are likely to influence engagement (Bandura, 1997; Connell, 1990; Connell & Wellborn, 1991; Deci & Ryan, 1985, 2000; Gillet, Vallerand, & Lafreniere, 2012). We examine how past scholars have conceptualized and operationalized the relationship between these concepts below.

Antecedents of Engagement

Theory and research suggest that student engagement in school is directly related to a student's motivation and sense of self-efficacy. Bandura (1997) theorizes that efficacy is malleable, and can be positively reinforced through social persuasion and by creating an environment that promotes success. Self-determination theory (Deci & Ryan, 1985, 2000) suggests that a person's motivation is directly linked to the extent to which he or she feels competent, autonomous, and related. Similarly, Connell (1990) and Connell and Wellborn (1991) argue that intrinsic motivation is positively related to levels of engagement. We hypothesize that teacher-family communication that promotes students' sense of competence (or efficacy) and enhances their feelings of relatedness to the teacher or school, can foster higher levels of student motivation. We posit that having teachers communicate directly with students is

likely to improve their sense of competence and relatedness. Researchers have found suggestive evidence of the positive relationship between school-to-family communication and student outcomes (Fan & Williams, 2010; Rumberger, 2011; Sirvani, 2007). It is possible, however, that negative teacher-parent communication that is focused on increasing parental monitoring of student behavior and school-work could decrease students' sense of autonomy and engagement.

Teacher-student communication may also affect students' extrinsic motivation. Regular teacher-parent communication provides parents with information about their child's performance in school that they might not otherwise have access to. Through this sharing of information, teachers and parents can partner to increase monitoring of student learning behaviors and create a unified source of extrinsic motivation for students.

Student Engagement and School-Related Outcomes

In their review of the literature on student engagement, Fredricks, Blumenfeld, and Paris (2004) divide engagement into three dimensions: behavioral, emotional, and cognitive. Behavioral engagement has been defined in several ways but may best be described as two sub-constructs: the avoidance of negative and disruptive classroom behaviors (Finn, 1993; Finn, Pannozzo, & Voelkl, 1995; Finn & Rock, 1997), and positive participation evidenced through attentiveness and asking questions (Birch & Ladd, 1997; Skinner & Belmont, 1993). The literature defines emotional engagement as related to student attitudes and affective responses towards schooling (Connell & Wellborn, 1991; Skinner & Belmont, 1993). Cognitive engagement is understood as students' investment in learning, and is defined both as their willingness to exceed requirements (Connell & Wellborn, 1991; Newman, 1992), and their motivation or ability to self-regulate (Brophy, 1987; Pintrich & De Groot, 1990).

Existing research has documented that students' engagement in school is continuously shaped by their relationships with adults and their schooling environment (Connell, 1990; Finn & Rock, 1997). A large body of evidence also highlights the important role that teachers play in molding student engagement (Battistich, Solomon, Watson, & Schaps, 1997; Furrer & Skinner, 2003; Ryan & Patrick, 2001). Specifically, demonstrated teacher caring has been shown to be associated with increases in students' academic effort (Wentzel, 1997, 1998), which is suggestive of how emotional engagement might translate into cognitive engagement. Parents also play a central role in shaping their children's behavior and engagement in school. Earlier work has shown that involving parents in their children's schooling can improve students' academic achievement (Barnard, 2004; Seitsinger et al., 2008).

The Efficacy of Teacher-Family Communication

These existing studies suggest that an intervention focused on teacher and parent communication could increase student motivation, efficacy, engagement, and ultimately academic achievement. Yet, almost no direct causal evidence can confirm this relationship. Several studies provide suggestive evidence that communicating with students' families by phone results in positive academic benefits (Bittle, 1975; Bursztyn & Coffman, 2010; Chapman & Heward, 1982). Bittle's (1975) small-scale study used pre-recorded, automated phone calls to parents from teachers and found that the calls generated more parent-initiated contacts with teachers and improved student's spelling performance. Chapman and Heward (1982) replicated the Bittle experiment in a special education classroom and found similar results. Though both studies examined communication between teachers and parents, their results rely on changes in one classroom and are not contrasted against comparable trends in a control group.

Existing experimental evidence is limited to studies using written reports to parents about students' in-school behavior. A small-scale study of four Algebra I classes in Texas found that sending individualized "monitoring" reports home to parents twice a week for twelve weeks increased homework completion and decreased disciplinary referrals among the treatment group (Sirvani, 2007a & 2007b). In a larger study, Bursztyn and Coffman (2010) conducted randomized trials with parents living in the favelas of Rio de Janeiro, Brazil. Through the use of text messages to alert parents to their child's attendance or absence from school they found that parents show a clear preference for receiving such communication. We add to this literature by examining whether personalized teacher-family communication affects widely recognizable and easily measured indicators of student engagement.

III. Research Design

MATCH Charter Schools and Teacher Residency

We conducted this experiment during the 2010 summer academy at MATCH Charter Public Middle School and High School. Like many Boston Public Schools, MATCH serves a largely low-income, minority student population; 78% of students are eligible for free or reduced priced lunch and 93% of students are Hispanic or African-American. Students at MATCH are admitted through a lottery, with students entering in grades six and nine, the first grades in their middle and high schools. Incoming 6^{th} and 9^{th} grade students are required to attend a four-week summer academy in which they take a mathematics class, two English (fiction and non-fiction) classes, and a class about the norms of the schools.

In addition to educating students, MATCH also operates the MATCH Teacher Residency, a year-long teacher training program embedded within the schools. Resident teachers

spend the academic year working as tutors for a group of 7-8 students as well as developing their teaching practices in small classes one day a week. The resident teachers then become the instructors of the MATCH summer academy, which serves as the student teaching practicum requirement for their initial teaching license.

In 2010, a total of 145 rising 6th and 9th grade students attended the MATCH summer academy. The summer academy schedule is organized so that students take all of their classes with the same classmates throughout the program. These intact class-taking groups consisted of approximately ten students, resulting in a total of 14 groups. Each of the 21 resident teachers taught two sections of the same subject such that there were 42 unique classes during each day of the summer academy.

Clustered-Randomized Assignment

In order to isolate the causal effect of teacher-family communication on student engagement, we designed a cluster randomized trial that addressed concerns about both equity and potential spillover effects. We began by randomly assigning students to their class-taking groups. We then randomly assigned seven of the 14 class-taking groups to either the treatment or control condition so that students in the treatment group would only attend classes with their treatment-group peers. By assigning treatment at the class-taking-group level, we eliminate the potential for any spillover effects due to students in the treatment group interacting with their control-group peers in the same classroom (Cook, 2005).

Our treatment effect is most accurately described as the joint impact of teacher-family communication on individual students' engagement combined with any potential treatment-group peer effects. It is unclear whether these potential peer effects will have a net positive or negative effect on engagement. More engaged peers might reduce the number of classroom

distractions and increase the quality of class discussions. However, a student might have fewer opportunities to participate in class if other students dominate the discussion, or the classroom climate might suffer if one student responds negatively to the increased communication.

We were able to prevent the potential confounding of teacher quality with the treatment effect by randomly assigning one class of treatment students and one class of control students each to a "trio" of three teachers (mathematics, fiction, and non-fiction). Scheduling restrictions at the schools dictated which teachers would be grouped together in a trio. We present the exact pairing of teachers and class-taking groups in Table 1. As Panel A illustrates, two class-taking groups, one treatment and one control, were fully nested within each teacher trio at the middle school. Unique scheduling requirements at the high school resulted in trios of teachers such that two class-taking groups, one treatment and one control, shared the same fiction and non-fiction teachers but not the same mathematics teachers (Panel B). Thus, each class-taking group at the high school shared two English teachers in common with one other group, and a mathematics teacher with a different class-taking group. The resulting partial cross-classification of teachers across class-taking groups in high school poses an important challenge for our analysis.

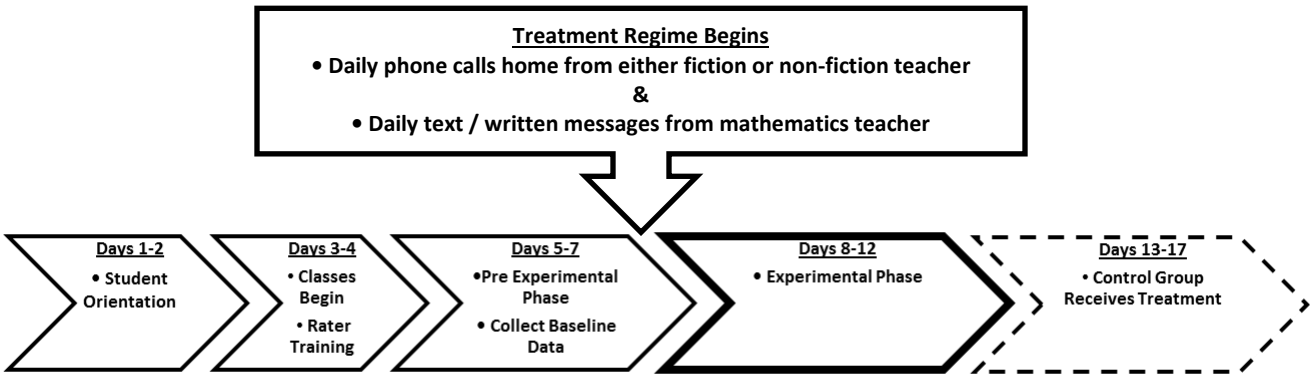
When students take classes from multiple teachers, their outcomes have the potential to co-vary as a function of the number, and specific combination, of teachers they share. While fully-nested data can be modeled with standard multilevel models, most multilevel-model software cannot fully account for the incomplete cross-classification of students and teachers, as is the case in our experiment. We describe our primary approach to account for the cross-clustered grouping of high-school students in our Data-Analysis section below. We also present a range of tests and alternative specifications in our Findings section to confirm that our approach does not cause us to underestimate our standard errors.

Experimental Intervention & Timeline

The experimental treatment consisted of two components of increased teacher communication. Students in the treatment group (n=69) were assigned to receive one phone call home per day from either their fiction or non-fiction English teacher. We instructed teachers to follow a common conversation protocol which consisted of three main components: evaluating the student's academic progress and classroom behavior, describing upcoming homework assignments and tests, and suggesting something the student should continue to do well or try to improve on. The call protocol was designed so that teachers could communicate positive, neutral, or negative information as appropriate, but would end with teachers affirming that the student could be successful and suggesting one specific way the student could maintain or improve their effort. These calls were shared across the two English teachers for each class-taking group assigned to treatment in order to lessen the overall burden of making the calls. In addition, treatment students were assigned to receive daily text/written messages from their mathematics teacher. We directed teachers to focus their texts/notes on the third component of the phone call protocol, identifying what the student had done well and encouraging them to continue doing it or, pointing out something the student could do better and affirming that they could improve. Although we explicitly instructed teachers that they were allowed to call students in the control group at any time, this high level of prescribed communication could have potentially crowded out additional calls. We present evidence that potential negative spillover effects did not crowd out calls to the control group later in the paper.

We provide a timeline of the study below. Students received treatment for a total of five consecutive days during the second week of the summer academy. In order to accommodate important concerns about equity, the treatment regime was switched to the control group (n=71)

midway through the summer academy. While this contamination of the control group prevents us from analyzing the persistence or fadeout of any treatment effects, it was the key design feature that allowed school administrators to gain parental support for the experiment.



We also asked teachers to complete daily communication logs to track the implementation of our treatment regime. These logs captured data on whether a call was made, whether someone answered the call, and who the teacher spoke with if someone did answer.[1]

At the end of the summer academy, each resident teacher also completed an anonymous survey that consisted of eleven open-response questions designed to elicit feedback about their experience implementing the focused communication. We also conducted four student interviews, two students each from 6th and 9th grade, to better understand students' perceptions of the increased communication. We combine these qualitative data with student demographic characteristics, which we use to examine the efficacy of our randomization process, and student academic data, which we use to demonstrate the association between student engagement and academic achievement. Demographic and achievement data include information such as race,

[1] Teachers typically made calls in the late afternoon when they had finished with their scheduled academic responsibilities. Teachers were expected to make at least one follow-up call at a later time in the evening if the first call did not result in a conversation. A research assistant followed up with any teacher that did not fill out their phone or text logs within 24 hours after the phone calls and text messages were scheduled to occur.

gender, age, low-income status, special education status, preferred home language, English proficiency status, end-of-course grades, and final exam grades.

Student Engagement Outcomes

In order to obtain fine-grained, reliable measures of student engagement, we designed a classroom observational protocol specifically for this purpose. We began by selecting and training a group of 16 raters to collect data for every single student in every class period during the summer academy. We trained raters to observe and record the total number of instances a teacher redirected a student's attention or behavior in a given class, *REDIRECT,* as well as the number of instances each student participated in a given class, *PARTICIPATE* .

Rater training took place in two phases. In the introductory phase, we trained raters on how to survey the classroom to simultaneously observe all (8-12) students and established criterion for what constituted a redirection or voluntary participation. Redirections were defined as instances in which the teacher clearly addressed herself to specific students in an effort to refocus their attention or to instruct them to improve their behavior. Participation was defined as instances in which students either voluntarily offered to respond to a question posed by the teacher to the entire class or independently asked a question or made a comment that was relevant to the academic content of the lesson. Raising a hand in response to a teacher's question to the class was coded as an instance of participation while responding to a question posed directly to a student was not.

The live phase of the training took place across two days at the beginning of the summer academy. Raters conducted four practice observations over two days, with debriefing sessions held after each observation to calibrate responses and resolve rating discrepancies. Throughout the experiment, we rotated raters across classes at each school to maximize the number of

possible rater-student combinations and to minimize any potential impact of rater bias. Additionally, raters were seated in the same location in each classroom.

We assigned randomized pairs of raters to observe the same students in the same class period in order to calculate inter-rater agreement rates. Using 816 pairs of ratings, we find a 66.3% exact agreement rate for redirections and a 73.9% "within two counts" agreement rate for participation.[2] We also calculate weighted kappa-statistics of 0.62 and 0.72 which measure the degree to which raters agree while also accounting for the probability of chance agreement.[3] These values are in the range of "substantial" agreement as define by Landis and Koch (1977), suggesting that raters were quite consistent at tracking instances of redirections and participation for all students in a class. Raters were kept blind to the assignment of treatment throughout the experiment to prevent any potential for rater bias across treatment and control groups.

We complement these observational measures of student engagement in the classroom with class-specific homework completion records. Daily homework assignments were turned in for each of the three academic classes upon arriving at school. School administrators reviewed the homework and recorded whether students had turned in an on-time, completed assignment. Using these data, we create a dichotomous variable *HWK_COMPLETE* and assign it a value of 1 if the homework was recorded as both complete and turned in on time.

Question Predictors

In our analyses, we seek to capitalize on all the information captured in our panel of data during the three day pre-experimental period and the five-day experimental phase. To do this, we first define an indicator variable *EXP_PHASE*, which takes on a value of 1 for all

[2] We report the "within two counts" agreement rate for our count variable of the number of times a student participated in class because of the large range (0-30). Counts of redirections ranged from 0 to 10.

[3] We specify weights as $1-\{(i-j)/(k-1)\}^2$, where i and j index the rows and columns of the ratings by the two raters in a two-rater ratings matrix and k is the maximum number of observed ratings. This weighted approach appropriately accounts for our count data by weighting the agreement rates by the degree to which the pairs of ratings differed.

observations captured during the five days of the experimental phase. This variable serves to capture any differences across the pre-experimental and experimental phases that are common to both the treatment and control group. We also define an indicator variable labeled *TREAT* for those students in class-taking groups who were randomly assigned to the treatment condition. We then interact each of these indicators to form our question predictor, *EXP_PHASE*TREAT*, which takes on a value of 1 for all class-period observations of students in the treatment group that occurred during the experimental phase of the study. This interaction term captures the Intent-To-Treat (ITT) effect of being assigned to receive teacher-family communication during the days in which students and their parents were receiving phone calls and text messages.

Analytic Sample

We obtained active written consent from the parents of 140 out of 145 students, a 97% consent rate. We construct a panel data set of three class-period observations per day for each of these 140 students captured over the course of the three day pre-experimental period and the five-day experimental phase. This data structure results in a student-day-class period data set that contains 3,360 potential observations (140 students * 3 class periods per day * 8 days). Isolated instances of student absences, students being removed from class, and students leaving school midway through the day reduce our final analytic samples. Our final sample includes 3,227 observations for our outcome *HWK_COMPLETE* and 3,060 observations for our classroom count variable outcomes, *REDIRECT* and *PARTICIPATE*.

Data Analysis

In our analyses, we seek to incorporate all of the information captured across our eight-day panel of data, while appropriately modeling the distinct data-generating processes and hierarchical nature of our data. We proceed by pooling our analyses across middle and high

school to improve our statistical power. Our primary quantities of interest are the Intent-To-Treat (ITT) effects of teacher-family communication on three measures of student engagement. These quantities represent the average treatment effect of being assigned to receive frequent communication. We focus our analysis on these ITT effects because they are the relevant quantities of interest for policymakers and principals when considering the actual effect a teacher-family communication initiative might have on student engagement.

We adopt a parsimonious multilevel modeling framework across all three outcomes following Raudenbush (1997, 2007) and Bloom et al. (1999) in order to account for the clustered nature of our data. In each model we specify two sets of random effects in addition to our mean-zero idiosyncratic error term: a set of random effects that are common to students within class-taking groups, μ_g, and a set of random effects for observations over time that are common to individual students, υ_{ig}. We assume these random effects are independent and identically distributed $\mu_g \sim N(0, \tau^2)$ and $\upsilon_{ig} \sim N(0, \sigma^2)$ where τ^2 is the between class-taking group variance and σ^2 is the between student variance, each independently estimated. Failing to include these terms would cause us to underestimate our standard errors, leading us to overstate our statistical power (Murnane & Willett, 2011).[4]

This multilevel modeling framework can then be flexibly applied to non-normally distributed outcomes if the distributions of these outcomes are known. We model our dichotomous outcome for turning in a completed homework assignment using a multilevel logistic regression model.[5]

[4] One potential concerns is that our assumption of normally distributed random effects does not hold in our small sample of class-taking groups (Angrist & Piske, 2009). We test the robustness of our findings to such a small-sample bias by replacing random effects for class-taking groups with fixed effect for these groups. We find that our results are consistent across both specifications.

[5] We fit multilevel logistic models using the xtmelogit command in STATA.

$$\text{(I)} \qquad P(HWK\_COMPLETE_{igt} = 1 | \, EXP\_PHASE, EXP\_PHASE * TREAT, C) = \frac{1}{1 + e^{-k}}$$

$$\text{where} \quad k = \beta_0 + \beta_1 EXP\_PHASE_t + \beta_2 EXP\_PHASE * TREAT_{gt} + \alpha' C_{ig} + (\mu_g + \upsilon_{ig})$$

Here $P(HWK\_COMPLETE_{igt} = 1)$ represents the marginal probability that student *i* in class-taking group *g*, turns in a completed homework on day *t* for a given subject. We present our parameter estimates as odds ratios in Tables 3 & 4 in order to allow for a more meaningful interpretation of our results. Our parameter of interest, β_2, captures the odds that students in the treatment group turn in an on-time, completed homework assignment divided by the odds that students in the control group do the same. Vector *C* represents a set of fixed effects for specific teacher combinations and academic subjects. This vector includes fixed effects for middle-school teacher trios to account for the fully-nested nature of class-taking groups in middle school. For high-school students, we account for the cross-clustered nature of class-taking groups by included one set of fixed effects for pairs of English teachers and another set of fixed effects for individual math teachers as outlined in Table 1. Because we estimate model (I) jointly across mathematics, fiction, and non-fiction classes, we also include fixed effects for academic subjects to control for any differences in outcomes due to the subject being taught.

We then model the causal effect of teacher-family communication on our two highly-skewed count variables of classroom engagement, *REDIRECT* and *PARTICIPATE*, using a multilevel negative-binomial model.[6] This model takes the same structural form as model (I) but instead assumes that the outcomes, and thus the idiosyncratic, mean zero error term have a negative binomial distribution.

We can express the stochastic component of our multilevel negative binomial model as:

[6] We fit multilevel negative binomial models using the PROC GLIMMIX command in SAS.

(IIa) $$\Pr(Y_{igt} = y_{igt}|\lambda, \delta) = \frac{\Gamma(\lambda_{igt}+y_{igt})}{\Gamma(\lambda_{igt})\Gamma(y_{igt}+1)}\left(\frac{1}{1+\delta_i}\right)^{\lambda_{igt}}\left(\frac{\delta_i}{1+\delta_i}\right)^{y_{igt}}$$

where $\Pr(Y_{igt} = y_{igt})$ represents the marginal probability that we observe *y* instances of an event *Y* for student *i* in class-taking group *g*, on day *t* for a given subject. Here the parameter λ represents the expectation of the number of events, conditional on the data and the dispersion parameter, δ. We express the parameter λ as a function of the same structural components specified in model (I):

(IIb) $$\lambda_{igt} = \exp[\beta_0 + \beta_1 EXP\_PHASE_t + \beta_2 EXP\_PHASE * TREAT_{gt} + \alpha' C_{ig} + (\mu_g + \upsilon_{ig})]$$

where λ represents the predicted number of times a student is redirected or participates in class. We present parameter estimates from model (II) as incidence rate ratios in Tables 4 and 5 for ease of interpretation. As before, β_2 is our parameter of interest, which captures the Intent-To-Treat effect of teacher-family communication on student classroom behavior (participation). Specifically, β_2 represents the ratio of the predicted number of times a student in the treatment group will be redirected (participate) per class period to the predicted number of times a student in the control group will be redirected (participate) per class period.

We complement these primary analyses with further exploratory analyses to attempt to better understand whether treatment effects might differ by grade level. To do this, we modify models (I) and (IIb) by replacing *EXP_PHASE*TREAT* with two mutually-exclusive indicators for observations of 6th grade students in the treatment group during the experimental phase, *EXP_PHASE*TREAT*6GRADE*, and for 9th grade students in the treatment group during the experimental phase, *EXP_PHASE*TREAT*9GRADE*. This specification allows us to

simultaneously estimate the Intent-To-Treat effect for the 6th and 9th grade cohorts. We then conduct Wald tests of the hypothesis that there is no difference between the estimated parameters associated with the 6th and 9th grade treatment effects in the population.

IV. Communication Increases Engagement

Fidelity of Treatment Implementation

Our findings focus on the effects of *prescribing* teacher-family communication. Although systems were in place to monitor and support teachers in the implementation of the treatment, phone call logs reveal that not every student received a phone call each day. The 69 students in the treatment group were assigned to receive a total of 345 phone calls across the five days of treatment. Of these 345 calls prescribed by the treatment, 299 calls were actually made by teachers – a compliance rate of 86.4%. Ultimately, only 54.9% of all prescribed calls resulted in a conversation with a parent or guardian. Text messages were delivered with an almost identical rate of success, with 298 of the 345 prescribed messages being sent.

Given the modest success rate in reaching parents, our ITT estimates of the average treatment effect of prescribing communication will necessarily understate the effect of communication on the engagement of those students who actually received the prescribed communication. However, it is possible that negative spillover effects could inflate our estimates if teachers' time for calling the parents of students in the control group was crowded out by the prescribed communication with the treatment group. Our detailed phone-call records indicate this was not the case. Teachers made a total of 35 phone calls to the parents of students in the control group during the experimental phase of the study. These records demonstrate that teachers were still able and willing to make calls to students in the control group when necessary.

Considering that the level of communication with students in the control group was far greater than the average frequency of teacher-family communication in U.S. public schools (Herrold et. al., 2008), our estimates likely understate the potential effect of communication in schools where little to no communication is the norm.

Primary Results

We begin by examining the validity of our random assignment by calculating treatment- and control-group averages for student demographic variables as well as pre-treatment measures of student engagement. We present these values in Table 2 along with the results of t-tests of mean differences across the treatment and control groups for each variable. We find no statistically-significant differences for any of the student demographic or pre-treatment measures of student engagement variables at an alpha level of 0.05 suggesting that our treatment and control groups are equal in expectation on both observed and unobserved characteristics.

We present averages of our three measures of student engagement during the pre-experimental and experimental phases as well as their differences in Table 3. These statistics reveal strikingly different trends across the treatment and control groups. On average, students in the control group became measurably less engaged over time; their homework completion rate dropped by over 6.5 percentage points, teachers had to redirect their attention more frequently, and they participated less in class. In comparison, students in the treatment group maintained their initial levels of engagement and improved their behavior; their homework completion rate dropped by only 0.6 percentage points, teachers had to redirect their attention less frequently, and their class participation increased. Importantly, the literature on student engagement suggests that engagement typically starts at high levels at the beginning of the school year and then varies in response to how students' efforts are being rewarded through teacher responses

(Skinner & Belmont, 1993) and academic outcomes (McIver, Stipek, & Daniels, 1991). As a result, evidence of an effective intervention could be one that raises engagement, that maintains initial levels of engagement, or that creates a less-dramatic drop off in levels of engagement. The trends presented in Table 3 provide initial evidence that teacher-communication affects student engagement by maintaining students' initial levels of engagement.

We present estimates from models (I) and (II) of the Intent-To-Treat effects of teacher-family communication on our three measures of student engagement in Table 4. Across all measures, we find that teacher-family communication had a large and positive effect on student engagement. We estimate that the odds students in the treatment group submitted an on-time completed homework were 1.4 times the odds that students in the control group did, which is statistically significant at an alpha level of 0.10. Because this estimate is marginally significant and consistent with the direction of our other two outcomes, we interpret it as suggestive of a true effect. This is equivalent to a 40% increase in the odds that a student turned in an on-time completed homework or a 4.1 percentage point increase in the predicted probability of turning in a completed homework relative to a control group mean of 83.5%.

We also find that teacher-family communication had a large effect on students' on-task behavior and classroom participation. Estimates from equation (II) show that students in the treatment group were redirected 0.75 times for every one time students in the control group were redirected (p=.07). Interpreting this incidence rate ratio as a percent change, we find that teacher-family communication reduced the frequency with which students' attention or behavior in class had to be redirected by 25%. We also find that students in the treatment group participated 1.15 times for each time students in the control group participated (p=.03), representing a 15% increase caused by teacher-family communication. Together, the consistent

direction and large magnitude of these estimates provide evidence of a direct causal effect of teacher-family communication on student engagement.

Testing for Grade-Specific Effects

We next explore whether communication might have affected the behavior of incoming 6th graders differently than 9th graders. It is important to note that while these grade-specific analyses provide suggestive evidence for designing future interventions, we do not have adequate statistical power to determine whether estimated differences across grades capture true heterogeneity or are the result of sampling idiosyncrasies. We present results from modified versions of models (I) and (II) as well as Wald tests of the difference between estimated treatment effects across cohorts in Table 5. These disaggregated results suggest that middle school students might have increased their homework participation by even more than high school students although we cannot reject the null hypothesis of no difference between grade-level effects. High school students appear to have reduced their off-task and inappropriate classroom behavior by more than middle school students although we again cannot conclude that our estimates are different. In contrast, our point estimates suggest that the effect of communication on class participation may have been entirely concentrated among 6th graders. Estimates from model (II) show that the odds that 6th grade students – who were assigned to receive focused teacher-family communication – participated in class were 49% greater than their control-group counterparts. The odds of participating among 9th grade students in the treatment group appear to have decreased by 16%. A Wald-test confirms that this difference in estimated treatment effects is statistically significant ($p<.001$).

That 9th graders participate less in class than 6th graders is not surprising given that, on average, students become progressively less engaged in school as they become older (Harter,

1981; Gentry, Gable, & Rizza, 2002; Yair, 2000). However, the decrease in participation among treatment-group 9th graders suggests that teacher-family communication negatively affected their willingness to engage in class. This differential effect of communication on participation rates across middle school and high school is not unique to our study. Fan and Williams (2010) find that school-family communication that focuses on problematic behaviors negatively affected the motivation of high-school students. In our study, it may be that 9th grade teachers focused more on negative behaviors when communicating with parents or that 9th grade students perceived this communication as focused on problem behavior. Thus, we provide further suggestive evidence that negative communication can diminish the intrinsic motivation of adolescent students, in particular, by limiting their autonomy and self-determination.

Student Engagement and Academic Achievement

Policymakers are likely to ask whether teacher-family communication increases student achievement. However, the compromise needed to facilitate our experiment – providing additional communication to everyone during the summer – does not allow us to answer this question directly. In Table 6, we present suggestive evidence of this relationship in the form of partial correlations between our measures of student engagement during the experimental phase of the study and academic achievement at the end of summer program, conditional on pre-experimental phase measures of engagement. These partial correlations show that intervention-induced changes in engagement are associated with student achievement. We find that homework completion is positively correlated with average summer academy end-of-course and final-exam grades (0.40 & 0.19). In addition, the average number of redirections students received is negatively correlated with end-of-course grades (-0.26). We do not find any relationship between participation and achievement, conditional on pre-experimental levels of

participation. These correlations combined with the large body of literature discussed above provide suggestive evidence that teacher-family communication affects important determinants of student achievement.

Tests of Error Variance Misspecification

Accounting for the complex nature of the cross-classification of students and teachers in high-school settings, where students attend multiple classes and teachers teach multiple classes, pushes the limits of existing statistical software.[7] To circumvent this problem in our analysis, we have included fixed effects for middle-school teacher trios as well as fixed effects for high-school English teacher duos and high-school mathematics teachers. However, even this approach does not fully capture the common experiences of class-taking-groups who share English and mathematics teachers. We adopt an alternative categorization for high-school teachers in our sensitivity analyses by classifying the four sets of English teacher duos as representing teacher trios in high school. This provides a tractable way to model the common experiences of students who share many of the same teachers.

We examined the sensitivity of our findings to our preferred approach to accounting for the common experiences of students in three ways. First, we assessed the degree to which students' outcomes are related across teacher trios. We did this by obtaining the residuals from simplified specifications of our models that do not include fixed effects for any teacher combinations, for each of our three outcomes of interest. Then, we treated these estimated residuals as outcomes themselves and conducted ancillary analyses to test whether their overall sample variation contained non-zero between-trio variance using one-way random-effect analysis of variance and treating "teacher-trios" as the between-group factor. If there existed meaningful variation across teacher trios then there would exist the possibility that any attempt to

[7] We thank an anonymous reviewer for raising these issues, and suggesting the sensitivity analyses.

account for the cross-clustering of students in high school, such as our fixed effects approach, might result in underestimated standard errors. We found that, for each of our three original outcomes, between-trio variability in the sample residuals was indistinguishable from zero and the corresponding intraclass correlation coefficients were all less than 0.001 (Table 7, Panel A). Second, we refit models (I) and (II), and included a level-4 random effect for teacher trios (Table 7, Panel B). The resulting parameter estimates and their associated levels of statistical significance are nearly identical to our primary results. Third, we refit models (I) and (II) while including fixed effects for each of the 21 individual teachers in our study as a more fine-grained approach to addressing the grouping of students within individual teachers in the structural part of our model. This again results in almost identical parameter estimates and associated significance levels (Table 7, Panel C). We conclude that our primary model specification, though potentially incomplete, does not induce a downward bias in our estimated standard errors, and that our substantive results are robust to our incomplete specification of the error-covariance structure as a result of the partial cross-classification of students and teachers in high school.

V. Exploring Potential Mechanisms

Three key mechanisms through which increases in teacher-parent and teacher-student communication caused changes in student engagement emerge from our teacher follow-up surveys and student interviews: stronger teacher-student relationships, expanded parental involvement, and increased student motivation. We illustrate these mechanisms using qualitative evidence collected during our study.[8]

Stronger Teacher-Student Relationships

[8]All names of teachers and students have been replaced with pseudonyms to protect their identities.

In our follow-up teacher survey, MATCH summer school teachers consistently described positive changes they experienced in their relationships with students. In their words, calling home and texting/writing notes "foster[ed] a better rapport" and "heightened our relationship" with students. This translated into increased intrinsic and extrinsic motivation among students to engage in class. Middle school teachers, in particular, perceived that their improved relations increased students' willingness to ask for help and to seek out approval and praise. Student responses in our interviews suggested that teachers' perceptions of improved rapport were shared by students. One young man at the high school remarked,

> "When she started giving me the notes it helped me start building a bond with the school, making me feel like it was my second home, like she was like a sister or mother to me, and giving me support, and if there was a problem knowing that she could help me fix it."

Three of the four students that we interviewed expressed similar views about how communicating with their teachers enhanced relational trust between them and their teachers.

Teachers also consistently described how their improved relationships with students helped them to be more effective at classroom management and behavior modification. Teachers perceived that these strengthened relationships allowed them to "ask more of [students] in class without risk of backlash," and caused students to be "much more willing to allow me to push them/talk them down." One high school mathematics teacher wrote,

> "Students had more trust and compliance when behavioral adjustments needed to be made. They didn't see it as a dictatorship but rather a reasonable request."

These quotes help to illustrate the likely ways in which more personalized communication promoted feelings of relatedness and efficacy among the students. However, not all high school students responded positively to the increased communication. A high school math teacher noted that one of her students "was mad I called his house all the time." This example illustrates

how students can respond negatively when they perceive communication to be further monitoring and behavior management.

Expanded Parental Involvement

A second complementary mechanism that likely contributed to improved student engagement was enhanced parental involvement (Epstein, 2010). Parent involvement in their children's academics is often limited by the information asymmetry that exists between students and their parents, especially with students in secondary school who see five or more teachers in a day. Phone calls home provide parents with detailed information about their child's academic progress and behavior that has not been filtered by students. Students may then become more accountable at home for their actions and efforts in school. MATCH teachers frequently mentioned instances where a phone call home provided them with increased "leverage." These calls also allowed parents to provide teachers with important information and to suggest strategies for addressing inappropriate behavior that were successful at home. For instance, a middle school fiction teacher described one such experience during the experiment:

> "Jorge had a pretty bad day . . . which I discussed in depth with his dad. We discussed ways to bring positive attention to him without allowing room for misbehavior. I never had any trouble with him behaviorally after that point."

Communicating with parents also allowed teachers to provide specific advice about ways in which parents could support the academic achievement of their child. A fiction teacher wrote,

> "Earl's reading quiz scores were steadily decreasing. I spoke with his mom a couple of times about the necessity of reading really carefully during his homework. His grades went up significantly."

Teachers can empower parents by providing them with information about an area in need of improvement and by giving them guidance on how to help their child to improve.

Students also noted that the increased involvement of their parents affected their own perceptions of, and response to school.

> "I felt relieved that the school actually wanted family support, and then it was also, kind of weird with my mom asking me about this, because usually a school won't call home, they will just make it the parents' responsibility to call, but this school they actually want to get the parents involved."

Here a high school student is expressing his surprise about the proactive rather than reactive nature of the calls home. Both middle-school students we interviewed expressed similar reactions to the phone calls home. All four student interviewees mentioned that their general conception of when a teacher would call home was related to something being wrong or their being in trouble.

Increased Student Motivation

Finally, many teachers described ways in which teacher-parent and particularly teacher-student communication impacted student engagement by increasing student motivation. For example, when a high school fiction teacher was asked about how increased communication affected her relationships with students she wrote:

> "During the time the increased communication occurred my students definitely showed more interest and investment in their learning. For instance, some would call or text [me] to clarify [homework] problems etc. Students inquired on their own accord as to how they did in the class."

Several teachers also wrote that students responded positively to the challenges they posed in their texts and notes. Examples of such texts include, "Thank you for responding so professionally to your demerit today. I know that your talking reflects your enthusiasm and I'd love to see you channel that into a hand raise!" and, "I know that math might not be your favorite subject, but I am looking forward to seeing the courage I know you have as you continue to contribute in class!" One teacher described how a middle school student was particularly

motivated by being awarded "all-star status" on a note for his behavior and participation in class. From then on, the student inquired about what it would take to earn "all-star status" on the final exam. "It's quite likely that Tyson would not have made it through my class had he not had that motivator," his teacher asserted. These examples emphasize how communication can promote students' sense of competence, and thus their intrinsic motivation, by reinforcing positive behavior and setting manageable goals.

VI. Designing an Effective and Sustainable Communication Intervention

Having documented the effects of teacher-communication on student engagement in this pilot experiment, we next consider what an optimal communication intervention might look like in the future. The primary cost to schools of promoting increased communication between teachers and families is the opportunity cost of teachers' time. Teachers' responses on our follow-up survey suggested that calling home less frequently could save teachers' time and potentially increase the effectiveness of teacher-parent communication. More than half of the teachers reported that the daily calls began to feel "forced" and "inauthentic," and perceived that this limited the effectiveness of the communication. Several teachers also reported that parents simply stopped answering their calls. This perception is supported by the data which show that the percentage of calls resulting in a live conversation with a parent or guardian fell steadily over the treatment week from 75.8% to 56.0%. Teachers suggested that calling on a less frequent basis would increase the effectiveness of teacher-parent communication because calls would become more genuine and merit greater attention.

Teachers also suggested that calling a predetermined list of students regardless of the day's events was an inefficient approach to teacher-parent communication. They argued that allowing teachers to selectively call students in response to specific issues would save time and

potentially increase effectiveness. A more flexible communication intervention might allow teachers to reach out to parents and students with genuine praise or when a pressing behavioral or academic issue has arisen. However, such an intervention could result in a far lower than desired frequency of communication and an inequitable use of teacher-family communication. Existing evidence suggests that, without a formal expectation, phone calls will take place at alarmingly low levels. Our findings indicate that improved teacher-student relationships are facilitated by frequent, proactive calls made by teachers rather than reactive calls that focus on problems in the classroom. To be both efficient and equitable, communication interventions might combine aspects of flexibility with a minimum expectation about call frequency and content, to ensure that teachers make proactive calls and that all students benefit from the communication.

A final consideration in designing evaluations of future communication interventions concerns the potential for heterogeneous treatment effects. Differences in the developmental states of students across grade levels will likely alter the potential effect of teacher communication on student engagement. Given the suggestive evidence we find for differences in the effect of communication by grade levels, subsequent studies should be designed with sufficient statistical power to detect heterogeneous effects. This can be done by both recruiting larger pools of participating schools, teachers, and students as well as by conducting individual-randomized trials rather than cluster-randomized trials when possible and appropriate.

VII. Conclusion

In this experiment, we estimate the causal effect of daily teacher-parent and teacher-student communication on student engagement during one week of a mandatory summer

academy for entering 6th and 9th grade students at MATCH Charter Public School. We find large and immediate effects of communication on homework completion rates, classroom behavior and participation in class. The willingness and ability to complete homework and to be an on-task and active participant in class are important skills as well as key mediators of academic achievement in school. Students who are participating in the task at hand rather than misbehaving are far more likely to be absorbing instructional content and contributing positively to the learning of their peers (Figlio, 2007; Lavy, Paserman, & Schlosser, 2008). Teachers who spend less time addressing inappropriate behavior have more time for uninterrupted instruction. Studies have shown that teachers who are more effective at behavior management also produce higher student achievement gains (Grossman et al., 2010). In these ways, reducing the misbehavior and increasing the participation of a few students can create positive externalities for all students in the class.

Designing optimal teacher-family communication interventions is inherently difficult because the effect of communication is mediated through the effectiveness of the communicator and the context in which the communication takes place. The impact of communication is also likely to vary by the age and developmental stage of students. It is also important to acknowledge that the conditions that allowed us to conduct a randomized field experiment place limitations on the generalizability of our findings. Several aspects of this study are different from the typical context in U.S. public schools. The classes, while mandatory and academically rigorous, were during the summer, the teachers were all teachers in training, the class sizes were relatively small, and the students were all from families who were willing and able to actively enroll their child in a charter school. In addition, our experiment took place over a short period of time and involved a higher frequency of communication than would likely occur over the

course of a full academic year. Going forward, it will be important to replicate this work in other school settings, and with less-frequent and longer-term periods of increased communication, in order to better understand the role that the school context plays in moderating the effectiveness of teacher-family communication.

Schools would be wise to experiment with how they might set aside time for teachers to make these calls or facilitate other forms of communication with students and parents. For instance, an effective intervention might involve asking teachers to contact parents outside of traditional school hours. Formal time during the school day for communicating with parents and students could be provided to teachers by reallocating it from other non-academic duties such as lunch supervision or hallway monitoring. Similarly, schools could work with teachers to identify other ineffective uses of teachers' time that could be better used to experiment with different teacher-family communication strategies. Administrators could work with teachers to increase buy-in and refine best practices before attempting to make a broader culture shift in the norms around teacher-family communication at a school.

Teachers can be valuable partners in designing experiments to test enhanced teacher-family communication. In a follow-up survey, MATCH resident teachers suggested that a less time-intensive, and potentially more effective, yearlong intervention would have teachers calling home every few weeks with the flexibility to make calls when they were most needed. Despite this thoughtful feedback, schools should exercise caution when considering communication interventions without minimum communication expectations and documentation systems. Given the important role that the phone-call tracking and follow-up system played in this experiment, we believe that without such systems mandated teacher-family communication would likely suffer from low implementation rates.

Discerning what teacher practices affect student behavior, engagement, and achievement continues to be a challenging and critically important task for education researchers. This experiment serves as an example of how researchers and practitioners can partner to conduct rigorous causal research on specific teaching practices in U.S. public schools. It should also serve as motivation for future studies that investigate whether the immediate increase in student engagement that we find can be maintained throughout the academic year. Subsequent studies might also attempt to explore the effect of less frequent teacher-family communication on longer-term outcomes such as semester grades, standardized test scores, and high-school graduation rates. Our goal as researchers should be to identify the type and frequency of teacher-family communication that sustains student engagement throughout the year without overwhelming teachers or causing them to forgo other important aspects of their professional practice. Although we do not yet know the parameters of an optimal communication strategy, these findings strongly suggest that formalized and frequent teacher-family communication can have an immediate effect on important mediators of student academic achievement.

Tables

Table 1: The Cross-classification of Class-taking Groups and Teachers across Middle School and High School

Panel A. Middle School

Class-taking Group	Experimental Condition	Mathematics			Fiction Teachers			Non-Fiction Teachers			Teacher Trios
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	
1	Treatment	x			x			x			a
2	Control	x			x			x			a
3	Treatment		x			x			x		b
4	Control		x			x			x		b
5	Treatment			x			x			x	c
6	Control			x			x			x	c

Panel B. High School

Class-taking Group	Experimental Condition	Mathematics Teachers				Fiction Teachers				Non-Fiction Teachers				English Teacher	Math Teacher
		(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)	(S)	(T)	(U)		
7	Treatment	x						x		x				d	i
8	Control			x				x		x				d	ii
9	Treatment				x		x					x		e	iii
10	Control		x				x					x		e	iv
11	Treatment		x			x							x	f	iv
12	Control				x	x							x	f	iii
13	Treatment			x					x		x			g	ii
14	Control	x							x		x			g	i

Table 2: Average Student Demographic Characteristics and Pre-experimental Measures of Student Engagement across Treatment and Control Groups

	Treatment	Control	Difference	p Value
Student Demographic Characteristics				
Female (%)	44.9	43.7	1.27	0.88
African American (%)	60.9	66.2	-5.33	0.52
Hispanic (%)	37.7	25.4	12.33	0.12
Low-income (%)	73.5	85.3	-11.76	0.09
Limited English Proficient (%)	30.4	16.9	13.53	0.06
Native English Speaker (%)	73.9	76.1	-2.14	0.77
Individualized Education Program (%)	13.0	19.7	-6.67	0.29
Age (years)	12.5	12.7	-0.20	0.42
n[a]	69	71		
Pre-experimental Measures of Engagement				
HWK_COMPLETE (%)	80.5	85.2	-4.70	0.194
n[b]	591	610		
REDIRECT (per class period)	0.61	0.42	0.19	0.09
PARTICIPATE (per class period)	5.84	6.25	-0.41	0.54
n[c]	588	591		

Notes: The maximum potential number of pre-experimental observations for the treatment and control groups are 621 and 639, respectively (69/71 students x 3 days x 3 class periods per day).

[a] Student demographic characteristics are measured in a student-level data set.

[b] Pre-experimental measures of engagement are measured in a student-day-class period data set. These observations are collected across three pre-experimental days in which students attended three classes per day.

[c] See note for *b*. There are slighly fewer obsevation for redirections and paticipation because of isolated instances when students turned in their homework at the beginning of the day, but left school early and were not observed in class.

Table 3: Average Student Homework Completion, Behavioral Redirection, and Participation Rates per Class Period During Pre-experimental and Experimental Phases

	Pre-experimental	Experimental Phase	Difference
HWK COMPLETE (%) n=3,227			
Treatment	80.5	79.9	-0.66
Control	85.2	78.7	-6.56
REDIRECT (per class period) n=3,060			
Treatment	0.61	0.52	-0.10
Control	0.42	0.51	0.08
PARTICIPATE (per class period) n=3,060			
Treatment	5.84	6.08	0.24
Control	6.25	5.90	-0.35

Notes: The pre-experimental and experimental phases consisted of three classes observed over the course of three and five days, respectively. The reported sample sizes refer to the number of student-day-class period observations available in our analytic sample. There are 167 more class-period observations for homework completion because of isolated instances when students turned in their homework at the beginning of the day, but left school early and were not observed in class. With 140 students in our sample, three periods per day, and eight total days of observations, the maximum sample size we could have observed was 3,360. The slightly fewer observations for our two count variables are created by the summer academy's routine for submitting homework. Each morning students submit their homework as they enter the school. Therefore, we obtained valid observations for HWK_COMPLETE for every student who showed up to any part of the day even if they did not attend all of their classes.

Table 4: Parameter Estimates of the Intent-To-Treat effect of Teacher-family Communication on Homework Completion, Behavioral Redirection, and Participation Rates per Class Period

	HWK_COMPLET	*REDIRECT*	*PARTICIPATE*
	(I)	(II)	(III)
EXP_PHASE	0.63 *	1.15	0.92 *
	[3.47]	[1.46]	[2.45]
*EXP_PHASE*TREAT*	1.40	0.75 ~	1.15 *
	[1.92]	[2.23]	[2.80]
n	3,227	3,060	3,060

Notes: ~p<.10, * p<0.05, ** p<0.01, *** p<0.001. Logistic model estimates for homework completion (*HWK_COMPLETE)* are presented as odds ratios and t-statistics [t-stat]. Negative binomial model estimates for behavioral redirection (*REDIRECT)* and class participation (*PARTICIPATE)* are reported as incidence rate ratios and t-statistics [t-stat]. P-values are calculated using six degrees of freedom for the treat-control contrasts within the seven approximate teacher trios. All models include random effects for class-taking groups and students as well as controls for class-subjects.

Table 5: Parameter Estimates of the Intent-To-Treat Effect of Teacher-family Communication Estimated Separately for 6th Graders and 9th Graders

	HWK_COMPLETE	*REDIRECT*	*PARTICIPATE*
	(I)	(II)	(III)
EXP_PHASE	0.63 *	1.15	0.92 *
	[3.47]	[1.46]	[2.50]
*EXP_PHASE*TREAT*6GRADE*	1.54 ~	0.83	1.49 ***
	[2.08]	[1.17]	[6.88]
*EXP_PHASE*TREAT*9GRADE*	1.23	0.65 *	0.84 *
	[0.90]	[2.57]	[2.82]
n	3,227	3,060	3,060
Test for differential grade effects			
Wald Statistic	0.75	2.08	158.17
P-value	0.387	0.150	0.000

Notes: ~p<.10, * p<0.05, ** p<0.01, *** p<0.001. Logistic model estimates for homework completion (*HWK_COMPLETE*) are presented as odds ratios and t-statitics [t-stat]. Negative binomial model estimates for redirections (*REDIRECT*) and class participation (*PARTICIPATE*) are reported as incidence rate ratios and t-statistics [t-stat]. P-values are calculated using six degrees of freedom for the treat-control contrasts within the seven approximate teacher trios. All models include random effects for class-taking groups and students as well as controls for class-subjects and grade-level.

Table 6: Partial Correlation Coefficents between Average Measures of Student Engagement During the Experimental Phase, Controlling for Pre-treatment Levels of Engagement

	Homework Completion	Redirection	Participation
End-of-Course Grade	0.400***	-0.264**	0.020
Final Exam Grade	0.186*	-0.001	0.060

Notes: * p<0.05, ** p<0.01, *** p<0.001. We calculate averages for every student during the 3 pre-experimental days and 5 experimental days.

Table 7: Tests of Error Variance Misspecification

	HWK_COMPLE	*REDIRECT*	*PARTICIPATE*
	(I)	(II)	(III)
Panel A: One-way random-effects anovas			
Between Teacher Trio Sums of Squares	1.84	0.36	3.43
Withing Teacher Trio Sums of Squares	2522.61	2818.85	7661.86
Trio	0.39	0.07	0.23
p-value	(0.88)	(0.99)	(0.97)
Intraclass Correlation	0.001	0.000	0.000
Panel B: Teacher Trio Random Effects			
*EXP_PHASE*TREAT*	1.42	0.76 ~	1.14 *
	[1.93]	[2.08]	[2.63]
p-value	(0.10)	(0.08)	(0.04)
Panel C: Individual Teacher Fixed Effects			
*EXP_PHASE*TREAT*	1.41 ~	0.77 ~	1.16 *
	[1.95]	[2.01]	[3.03]
p-value	(0.09)	(0.09)	(0.02)
n	3,227	3,060	3,060

Notes: ~p<.10, * p<0.05, ** p<0.01, *** p<0.001. Logistic model estimates for homework completion (*HWK_COMPLETE)* are presented as odds ratios and t-statistics [t-stat]. Negative binomial model estimates for behavioral redirection (*REDIRECT)* and class participation (*PARTICIPATE)* are reported as incidence rate ratios and t-statistics [t-stat]. P-values are calculated using six degrees of freedom for the treat-control contrasts within the seven approximate teacher trios. Teacher trio random effects models (Panel B) include random effects for class-taking groups and students as well as controls for class-subjects. Individual teacher fixed effects models (Panel C) include random effects for students as well as controls for class-subjects.

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