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Can Technology Transform Communication between Schools, Teachers, and Parents? Evidence from a Randomized Field Trial

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Abstract

We study the adoption and implementation of a new mobile communication app among a sample of 132 New York City public schools. The app provides a platform for sharing general announcements and news as well as engaging in personalized two-way communication with individual parents. We provide participating schools with free access to the app and randomize schools to receive intensive support (training, guidance, monitoring, and encouragement) for maximizing the efficacy of the app. Although user supports led to higher levels of communication within the app in the treatment year, overall usage remained low and declined in the following year when treatment schools no longer received intensive supports. We find few subsequent effects on perceptions of communication quality or student outcomes. We leverage rich internal user data to explore how take-up and usage patterns varied across staff and school characteristics. These analyses help to identify early adopters and reluctant users, revealing both opportunities and obstacles to engaging parents through new communication technology.

JEL Codes: I20, I21, D83

I. INTRODUCTION

Throughout the last century, reformers and policymakers have looked to technology as a potential transformative force in education. The radio, overhead projector, video, handheld calculator, computer, and smartboard were all seen as revolutionary new educational tools at one time. More recently, advances in information technology have created opportunities for personalized learning through adaptive tutoring programs, Massive Open Online Courses, and flipped classrooms. Now, new mobile communication technology is starting to fundamentally change the ways in which schools and teachers communicate with parents.

There now exists a large marketplace for mobile communication applications (apps) designed to reduce information frictions and increase coordination between schools, teachers, parents, and students. For example, the communication app Class Dojo supports 35 million users across 180 countries, has raised $65 million in venture funding, and carries a valuation as high as $400 million (Wan, 2019). Edmodo, another education-technology communication app, reports a network of more than 100 million users (Edmodo, 2020). Despite the growing demand for mobile communication apps, little is understood about who uses them, how they are used, and what their effects are on communication frequency and quality.

Mobile apps hold particular promise because of their potential to reduce many of the barriers that exist with the most common forms of communication between schools and families. Phone numbers quickly become outdated and backpack letters often don't make it into parents' hands. Limitations in computer access, technological proficiency, and English fluency prevent many families from benefitting from email communication or online gradebooks. Mobile apps aim to overcome these challenges by taking advantage of the near universal access to

smartphones (Pew Research Center, 2018), reliability and convenience of text messages, and advantage of automatic translation features.

In this paper, we study the implementation of SchoolCNXT, a mobile communication app, and evaluate the importance of user supports for maximizing app usage and efficacy among a sample of 132 New York City (NYC) public schools. Research on the efficacy of communication technologies in health care and sales has found heterogeneous effects on organizational effectiveness depending on the quality of training and support provided to employees (Ahearne et al., 2004; Cresswell & Sheikh, 2013). However, there exists little empirical evidence on how to promote the successful adoption and use of new communication technologies in education. We evaluate the effects of supplementing access to SchoolCNXT with intensive implementation supports to explore if these supports increase the amount of effort school staff – teachers, administrators, counselors/social workers/psychologists, and administrative assistants – invest in communicating via the app and the subsequent return on this effort.

We provided all participating schools with free access to SchoolCNXT and randomly assigned them to receive either basic supports or more intensive training, guidance, monitoring, and encouragement to leverage the new technology. Intensive supports included school visits from a SchoolCNXT coordinator, in-person and online training sessions tailored to individual schools' needs, assistance with parent enrollment, regular personalized communication with administrators that included usage reports and tips, and individual and school-wide recognition incentives for active users. Basic supports consisted of webinar training sessions, a standard technical support hotline, and general product emails.

Our study makes several contributions to the literature. We develop a conceptual framework for teachers' decisions about the amount of effort they invest in communicating with parents and the return on this investment. This stylized model helps to elucidate the potential benefits of adopting mobile communication apps. We conduct the first randomized field trial of implementation supports designed to facilitate the widespread adoption and successful use of a mobile communication app. Finally, we use rich internal user data from the app to provide a detailed, data-driven account of how schools adopt and implement new mobile communication technologies as well as to explore how take-up and usage patterns varied across staff and school characteristics. These exploratory analyses help to identify early adopters and reluctant users, revealing both opportunities and obstacles to engaging parents through new communication technology.

We find that providing free access to SchoolCNXT with only basic supports to control schools resulted in, on average, relatively low levels of adoption of the new technology. Only 48% of staff members and 15% of parents in the control group ever logged-in to the app to activate their accounts. In addition to app activation, total usage rates were also low among the control group, with an average of 2.5 total incidents of use (i.e. sending a message or posting, clicking on, liking, or saving a news item) during the academic year among staff who activated their accounts.

Providing intensive user supports to schools and teachers lead to moderate increases in app usage, primarily driven by increases on the intensive margin. Supports increased staff activation rates by 7 percentage points and more than doubled the low baseline rate of overall use. However, these increases in adoption and use in treatment schools did not measurably improve overall perceptions about the quality of communication among administrators, teachers,

or parents. Given the relatively low levels of activation and use of SchoolCNXT, even among treatment schools, it is not surprising that we find no effect of intensive user supports on student achievement or absenteeism.

We examine two possible hypotheses that might explain why intensive supports had little effect on communication quality. One potential explanation is that school staff and parents may require an initial implementation year to familiarize themselves with the new technology before they adopt it more readily. However, internal app usage data from the following year reveal that total use among staff declined about 15% across treatment and control schools and remained relatively unchanged among parents.

A second possible explanation is the narrow treatment-control contrast between intensive user supports and basic user supports. We examine the broader effects of providing free access to the SchoolCXNT app by conducting a matching analysis where we compare outcomes for the 132 participating schools in our study to those from observably similar NYC schools that did not have access to SchoolCNXT. The large pool of non-participating NYC schools allows us to apply Coarsened Exact Matching (CEM) methods, which produce a comparison group that closely approximates the observed characteristics of participating schools. Results from our CEM analyses reveal that providing free access to SchoolCNXT (with at least basic supports) caused significant improvements in teachers' overall perceptions about teacher-parent communication quality. However, we find no effects on parents' perceptions of teacher-parent communication quality or student outcomes.

We conclude by exploring the black box of who, when, and how school staff and parents used the SchoolCNXT app. For example, teachers primarily used the two-way messaging feature, while administrators largely posted news announcements. Better understanding who

adopts new mobile communication apps and how they use them can inform efforts to maximize the efficacy of these new communication platforms. Such continuous improvement efforts are critical given school-parent communication remains infrequent and unsystematic in most schools.

II. PRIOR LITERATURE

A. Parent Engagement in Schools

A large literature documents the benefits of parents engaging with schools to support their students' learning. Studies show that parents play a key role in supporting student achievement by fostering positive learning environments at home and engaging in their students' schooling (Todd & Wolpin, 2007; Houtenville & Conway, 2008). Goodall and Montgomery (2014) describe parental engagement as a continuum from basic involvement to engagement. On one end of the spectrum parental involvement is largely a one-way flow of information from schools to parents. A classic example of this is back-to-school nights where parents are quickly shuffled from one classroom to the next to hear from teachers about class curricula and activities. On the other end of the continuum, parental engagement is characterized by agency and active involvement in their student's learning, with information flows that are two-way between school and home. An example of this includes parents communicating with teachers and co-developing a support plan tailored to a student's unique strengths and weaknesses. While there is considerable variation in the specific actions that make up parental engagement, evidence from correlational, quasi-experimental, and experimental studies consistently find positive

relationships and effects of engagement across multiple outcomes including student achievement, behavioral and social skills, and educational attainment.[1]

Maximizing benefits from parental engagement, however, can be difficult and requires that schools maintain healthy, carefully cultivated relationships with parents. Research consistently finds schools' outreach efforts are not equally successful with all parents due to language barriers, the timing of school events, and unconscious biases (Calarco, 2015; Lareau, 2000; Rudney, 2005; Smith, 2000; Vincent, 1996). Schools' communication approaches often align with the preferences of higher-SES families, leaving low-income families and families of color struggling to connect despite a strong desire on the part of these families to be involved in their child's learning (Cooper, 2009; Crozier, 2001; Crozier & Davies, 2007; Goodall & Montgomery, 2014; Kim, 2009; Turney & Kao, 2009).

B. Prior Research on Parent Communication

Nationally representative data on the frequency and quality of school-initiated personalized communication with public school parents show that communication in any form between schools, teachers, and parents is surprisingly rare (Noel et al., 2016). For example, in 2012, 59 percent of public school parents reported *never* receiving a phone call home from their school during the previous year. The data also suggest there is considerable room for improvement in the quality of communication. About half of all parents were not "very satisfied" with the interactions they had with school staff.

Overall trends across the previous decade suggest schools have not made much progress in improving the frequency and quality of communication with parents. As recent as 2016, 58

[1] Epstein, Simon, & Salinas, 1997; Fan & Williams, 2010; Fan, Williams, & Wolters, 2011; Goodall & Vorhaus, 2011; Henderson & Mapp, 2002; Joe & Davis, 2009; Jordan et al., 2000; Kennedy, 2009; Kim, 2009; Lopez & Donovan, 2009; Shaver & Walls, 1998; Van Voorhis, 2001.

percent of parents still reported never receiving a phone call home from their student's school (McQuiggan & Megra, 2017). Although the use of email as a form of school-parent communication has risen moderately, this increase has not benefitted all families equally. The percentage of higher-income parents that received an individual email communication from their school increased from 56 to 59 percent between 2007 and 2012 but remained flat at 48 percent for families living at or below the poverty line (Noel et al., 2016). These email communication gaps are unlikely to have closed in more recent years given the large socio-economic gaps in access to broadband internet that persist today (Pew Research Center, 2017). Findings from a 2016 NCES survey further highlight these inequities; only 8% of higher-income families reported not receiving an email, newsletter, or notice from their student's school, whereas nearly three times as many poor families reported such a lack of communication (McQuiggan & Megra, 2017).

One potential challenge schools face when attempting to enhance teacher-parent communication is encouraging and monitoring teacher effort. A growing literature has examined the efficacy of communication platforms that address this challenge by removing teachers from the equation altogether. However, research has shown that providing parents access to information via online gradebooks has almost no effect on student outcomes, largely because very few parents ever use these tools (Bergman, 2016; Bergman & Chan, 2017). Newer approaches have focused on efforts to push personalized information about grades, missing assignments, and absences directly to parents through automated notifications.

Experimental evaluations of personalized, automated notification systems find promising positive impacts on student achievement, attendance, and behavior.[2] Several studies also find that proactively pushing information and guidance to parents is particularly effective at improving outcomes among students from low-income families and students of color (Hurwitz et al., 2015; Kraft & Rogers, 2015; York et al., 2019) and that effects become more pronounced as information and guidance is tailored to individual students' needs (Doss et al., 2019). However, one-way, automated communication fails to tap teachers' individual knowledge about their students or allow for a two-way dialogue between school staff and parents. For example, teachers and parents might exchange information about how best to coordinate their efforts in support of a student. Whether new mobile communication platforms that allow for two-way communication can increase communication frequency and quality, and further benefit families remains an open question.

III. INTERVENTION & CONCEPTUAL FRAMEWORK

A. Communication Platform

SchoolCNXT is a mobile application designed to facilitate communication between schools, teachers, and parents. The app is a combined platform for both school-wide news and announcements as well as personalized, two-way communication between staff and parents. The user interface is similar to many popular social media sites, such as Facebook, which allow for individuals and groups of people to communicate easily.[3] SchoolCNXT generates user accounts based on staff and student records provided by school districts and then groups users based on

[2] Kraft & Dougherty, 2013; Bergman, 2015; Hurwitz et al., 2015; Kraft & Rogers, 2015; Mayer et al., 2018; Berlinski et al., 2016; Bergman & Chan, 2017; Bergman et al., 2020; Doss et al., 2019; Kraft & Monti-Nussbaum, 2017; York et al., 2019.

[3] Screenshots of the app can be found in Appendix Figure A

schools.[4] Once individuals have activated their accounts with school-provided credentials, they can communicate with others in their respective groups.

In addition to school-wide groupings, staff can create subgroups based on class rosters, parent-teacher associations, grade levels, or any other groupings. Public posting boards for each group provide a forum where members can post, read, and react to news items such as school-wide notifications, field trip reminders, or homework assignments given to students in class. Users have the option to click on news items to see more information, like the item, and save it for later viewing. The app also supports more personalized two-way communication via in-app text messages between and among staff and parents.

B. Implementation Supports Intervention

SchoolCNXT coordinators began providing basic supports to all schools that participated in the field experiment in late August 2016. The first of these was a welcome email from SchoolCNXT that included posters and letters describing the app and encouraging teachers and parents to activate their accounts. SchoolCNXT coordinators also led conference calls and hosted webinar trainings early in the fall semester to orient teachers on how to use the app. The only sustained basic supports included a technical support line that administrators could call and general product emails sent to all SchoolCNXT users.

Treatment schools received a range of additional, intensive supports. These included individualized monthly emails to administrators that provided tips and encouragement to use the app, in-person visits, staff trainings, incentives for school-wide use, and a full-time SchoolCNXT

[4] SchoolCNXT accounts are generated for listed guardians of students which we refer to as parents. Accounts are also generated for listed school staff including teachers, administrators, librarians, nurses, and guidance counselors. Teachers comprise about 85% of generated accounts with administrators, guidance counselors, and auxiliary staff each accounting for about 5% of accounts. Because of this sample composition and for simplicity, we refer generally to staff side users as teachers unless otherwise noted.

coordinator devoted to supporting the treatment schools. The monthly emails provided detailed information to principals about activation and usage rates for teachers and parents in their schools. They also included example action plans such as grade-level-specific calendars with tips aimed at encouraging parent-teacher communication across a variety of topics through the app. For example, the calendars suggested teachers provide parents with conversation starters about what students were learning, alert parents of chronically absent students, and send personalized messages to all families about what their students were doing well. SchoolCNXT provided four of these grade-level-specific monthly action-plan calendars over the course of the year.

SchoolCNXT coordinators proactively reached out to administrators and parent coordinators throughout the course of the year to plan school visits and discuss strategies to increase engagement with the app. These staff conducted at least one in-person visit to every treatment school where they participated in a range of activities including leading 30 different staff-wide trainings, conducting at least 14 parent activation events, and regularly attending parent-teacher conferences and parent-teacher organization (PTO) meetings. In addition to formal visits, implementation staff also conducted informal drop-ins to meet with administrators and teachers to discuss school-specific app use patterns and provide individualized support. Finally, SchoolCNXT incentivized app use by offering "Top School" and "Top Staff" certificates to schools and teachers who met various requirements including minimum activation rates and sustained use throughout the year. These certificates were symbolic in nature and did not come with any financial awards or other benefits.

C. Stylized Model of School Staff Investment in Communication

A conceptual framework for how teachers and other school staff members decide how much effort to invest in communicating with parents helps to shed light on the potential for

communication technologies to increase parent engagement and, ultimately, student outcomes. A large literature documents the importance of both teachers and parents in supporting students' educational success (e.g. Todd & Wolpin, 2007; Houtenville & Conway, 2008). Consider a stylized education production function where achievement depends on teacher, parent, and student inputs. We can model the benefits to students of teacher-parent communication, which operate through teacher and parent inputs, as follows:

$$Benefits = f\big(q(e,x)\big) * r * \alpha * l \qquad (1)$$

where the benefits of communication are a function of the quality-adjusted quantity of communication, *q*, which is itself a function of the effort, *e*, teachers and parents invest in communicating and a vector of different communication approaches, *x*. Communication approaches can vary across several dimensions including exchange types (one-way vs. two-way), specificity (individual vs. general), sentiment (positive vs. negative), and topic (e.g. academic, behavioral, social, administrative). Benefits increase at a decreasing rate relative to quality-adjusted communication, and thus effort, such that $f_q' > 0$ and $f_q'' < 0$. Communication inputs are scaled by the reliability of the communication method (r), the proportion of families with access to the communication method (α), and the degree that teachers and parents share a common language, l. Here, r, α and l are $\in [0,1]$ such that lower levels of reliability, access, and fluency in a common language reduce the benefits of communication.

Teachers and parents also incur costs associated with communicating. These costs are represented by:

$$Cost = g(e,c) \qquad (2)$$

where *c* denotes the convenience of using a communication platform. The convenience term captures differences in where and when communication methods can be used such as at school

versus in transit or at home, and during the workday versus in the evening. It also captures the psychic costs associated with a given communication method where some educators and parents may be more comfortable or familiar with certain methods compared to others, independent of effort costs. We assume that, after an initial learning curve, costs increase at a constant rate with effort implying $g'_e > 0$ and $g''_e = 0$ and decrease with convenience, $g'_c < 0$.

The optimal amount of effort from a teachers' perspective is where the marginal benefit of communicating equals the marginal cost. We assume teachers' utility is positively correlated to that of parents because they both value students' growth and development. Additional benefits to teachers from increased communication may include fewer classroom management challenges, increased self-efficacy, and higher job satisfaction. This can also be generalized to other school staff members including administrators who stand to benefit from improved school culture or guidance counselors/social workers/psychologists who can better support students' mental health through increased awareness about students' home environments.

For many teachers, benefits initially exceed costs so they invest effort in communicating with parents. However, because $f''_q < 0$ and $g''_e = 0$, the costs of communicating eventually exceed the benefits at a given level of effort. Teachers communicate at different rates because it takes less effort for some to produce a given quality-adjusted quantity of communication: they work with parent populations with different levels of access and language barriers; they have different preferences about the convenience of communication methods; and they have access to different types of communication methods with varying levels of reliability.

The stylized models represented in equations (1) and (2) help to highlight the potential benefits of using mobile apps for teacher-parent communication. These apps aim to maximize the return to teacher effort by: 1) increasing the reliability of communication, 2) expanding

access to communication among parents, 3) eliminating language barriers through automatic translation, and 4) increasing the quality-adjusted quantity of communication a teacher can produce at a given level of effort (i.e. increasing output of $q(e)$). At the same time, mobile apps impose new costs in the form of lowered convenience for those teachers that are unfamiliar and/or uncomfortable with these technologies.

D. Model Predictions

The conceptual framework generates several exploratory hypotheses that our experiment is designed to test. The intensive implementation supports were intended to help and encourage teachers and other school staff members to reallocate the effort they invested in communicating with parents from other forms of communication to the SchoolCNXT app. Individualized training and support aimed to lower the cost, c, of switching to SchoolCNXT. Usage reports also provided school administrators with a way to monitor teachers' transition to the new platform. We hypothesized that shifting communication to SchoolCNXT would increase the marginal benefits of schools' efforts to communicate through the four mechanisms described above: improving reliability, expanding access, providing a common language, and increasing production efficiency.

The hypothesized downward shift in a teacher's marginal cost curve for producing a given quality-adjusted quantity of communication with SchoolCNXT will result in a new equilibrium for many teachers where they are able to communicate more with parents while expending less effort to do so. Other teachers may choose to sustain the same amount of effort they were investing previously in communicating or to only invest the amount of effort required to produce the same amount of communication they had previously engaged in before adopting SchoolCNXT. In addition to shifting the marginal cost curve, the intervention also aimed to

increase teacher effort, and thus total communication, through monitoring and encouragement. Regular usage reports sent to principals in the treatment schools made teachers' communication efforts more transparent to principals. Teachers also received encouragement and nudges via posts within the app with ideas for what to communicate about. Finally, we hypothesized that potential increases in quality-adjusted quantity of communication due to these combined effects would improve perceptions of communication quality and, as inputs into the education production function, student outcomes.

V. METHODS

A. Research Design and Sample

The NYC Department of Education (DOE) Division of Family and Community Engagement recruited principals to the study through email and in-person presentations at district leadership meetings. Principals from 132 New York City public schools volunteered to participate in the study and received free access to SchoolCNXT during the 2016-17 academic year.[5] As shown in Table 1, the sample included a range of school types and levels including elementary, middle, K-8, and high schools as well as early childhood centers and schools that serve children with special needs. We randomized schools using a matched-pair design in two steps. First, we created non-bipartite matched pairs using a high-dimensional matching algorithm that optimized matches across a set of 42 covariates based on a Mahalanobis distance measure (Moore, 2012).[6] We then randomly assigned treatment to schools within the 66 matched pairs. The matched pair randomization approach produced well-balanced treatment and control groups with no statistically significant differences in observable characteristics.

[5] Participating schools received three consecutive years of free access to SchoolCNXT starting in 2016-17.
[6] Covariates include 12 school characteristics, response rates for the parent and teacher NYC school surveys, 20 items from the NYC parent school survey, and 8 items from the NYC teacher school survey.

Participating schools were broadly representative of NYC public schools as a whole, if not slightly more disadvantaged. Nearly 80% of students at schools in the experiment were eligible for free or reduced price lunch (FRPL) compared to the district-wide average of 74%, and 16% were designated English language learners compared to 13% across the district. The racial composition of students in participating schools was very similar to district-wide averages, with Hispanic and African American students comprising 44% and 33% of our sample, respectively. Teachers in participating schools were also quite representative of the larger district: 80% were female, 50% were white, and 22% were African American.

Administrators at ten schools never followed through on the basic steps necessary to register SchoolCNXT accounts for their schools. Four of these schools were randomized to the treatment condition and six to the control condition. As shown in Appendix Table B1, we find no statistically significant differences in observables across treatment condition for the schools that registered. We do not include teachers and parents from these schools in our primary sample given our interest in understanding how stakeholders use these apps when provided the opportunity. As an additional robustness check, we replicate our analyses but instead retain these schools and assign user values of zero for activation and usage outcomes although teachers and parents in these schools never had the opportunity to use the app (see Appendix Table F1).[7]

B. Data Sources and Measures

SchoolCNXT User Data: SchoolCNXT data capture information on user activations and messages sent as well as posts, clicks, likes, and saves of news items. SchoolCNXT records the time and date for each type of action, which totaled more than 118,000 from more than 4,300

[7] We predict the number of teacher and parent accounts based on student enrollment in our sample of 132 schools.

activated teacher accounts and 14,800 activated parent accounts.[8] We use these data to create three primary measures that capture overall app usage patterns among teachers and parents: *messages sent*, which is the total number of individual and group messages sent by a user; *news engagements*, which is the total number of user interactions with news items (posts, clicks, likes, and saves); and *total use*, which is the sum of messages sent and news engagements.

Administrator Surveys: We administered baseline and end-of-year surveys to the principal or an assistant principal at schools in the experimental sample. Items asked administrators to identify, for example, the top two methods of school-wide and individual teacher communication with families, respectively. Administrators also responded to questions about the frequency and content of these interactions and identified common obstacles teachers face when trying to communicate with families. As primary outcomes, we examine responses to two items on the end-of-year administrator survey measured on a five-point Likert scale from *Not at All Effective* to *Extremely Effective*: 1) "How would you rate the effectiveness of school/parent communication?" and 2) "How would you rate the effectiveness of individual teacher/parent communication?" Response rates for the baseline and end-of-year survey were 100% (n = 132) and 68% (n = 90), respectively. Despite the drop in response rate for the end-of-year survey, we find no difference in response rates across treatment and control groups as exactly the same number of schools in each condition responded.[9]

NYC Administrative Data: We use district-wide administrative data from the NYC DOE to examine a range of school, teacher, and student outcomes as well as for conducting our CEM analyses. Teacher records include annual salary, years at a given school, years in the NYC DOE,

[8] The NYC DOE added scrambled teacher IDs to these internal user records so that we could merge them with teacher administrative records.
[9] We provide formal attrition analyses in Appendix Table C1.

gender, race, and staff type. Student records include gender, special-education status, English language learner designation, FRPL status, race, days absent, and achievement in math and ELA.

NYC School Surveys: We use data from district-wide annual DOE school surveys administered to classroom teachers and parents to measure perceptions of communication quality. We focus our analyses on three items from the teacher survey and four items from the parent survey that assess the effectiveness of communication between schools/teachers and parents. Example items include, "At this school there is an expectation that teachers communicate regularly with families," from the teacher survey and "Teachers work closely with me to meet my child's needs," from the parent survey.[10] Respondents answered these items using a four-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*. Data on teacher and parent responses are publicly available at the school level and report the total incidences of each Likert-category response for each survey item. The district-wide response rates to the school survey in 2016-17 were 86% for teachers and 57% for parents.[11]

We create outcomes capturing teacher and parent perceptions about school communication quality by constructing school-level agreement rates for the three items from the teacher survey and the four items from the parent survey, respectively. A principal component analysis (PCA) suggests that each set of items captures a single latent variable measuring teacher and parent perceptions about school communication practices. These factors explain a large majority of the variation in teacher (77.6%) and parent (71.4%) survey responses. We construct each measure of communication quality by predicting the first principal component and standardizing it to have a mean of zero and unit variance.

[10] The full text for all NYC School Survey items we use are available in Appendix D.
[11] 2016-17 NYC survey response rates for control and treatment groups were, respectively, 88% and 84% for teachers and 57% for parents in both groups.

C. Randomized Controlled Trial

We estimate treatment effects by applying a common structural specification across models that accounts appropriately for the different data generating processes of our error terms. For approximately normally distributed outcomes, such as student achievement, we estimate treatment effects using the following OLS model:

$$Y_i = \alpha + \beta_1 TREAT_i + \delta X_i + \epsilon_i \,, \tag{1}$$

where Y_i represents a given outcome of interest for teacher, parent, or student i. The coefficient on *TREAT*, β_1, captures our estimate of the Intent-To-Treat effect of additional supports. We include a parsimonious vector of controls, X_i, for school characteristics in our preferred models to increase the precision of our results. These measures include student enrollment, average student absences from the previous year, a measure based on the NYC school quality report which evaluates the learning environment and student achievement, and the percent of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male.[12] When we examine student-level outcomes, we also include individual student controls for previous year absences, race, gender, and whether or not a student is an English language learner, has a disability, and is eligible for FRPL.

We model administrator responses to Likert-scale items about the quality of communication with families with an ordered logistic parameterization of Model 1 and report estimates as proportional odds ratios. We model count-measures of app use with a negative

[12] We construct the school quality measure from a principal components analysis of the annual NYC DOE School Quality Reports from the previous year. These reports rate a school across seven categories (rigorous instruction, collaborative teachers, supportive environment, effective leadership, strong family community ties, trust, and student achievement) continuously from 0 to 1. We keep the first component from a PCA on the seven categories and standardize it to have 0 mean and unit variance.

binomial parameterization of Model 1 and report the estimates as incident rate ratios.[13] We do not include matched pair fixed effects in our primary specifications as negative binomial and ordered logistic models perform poorly and do not always converge with high-dimensional fixed effects. For completeness, we provide available results for specifications which include matched pair fixed effects in Appendix Table G1 & H1. We also complement our average treatment effect estimates with a range of tests for heterogeneous effects across individual teacher and school characteristics. Given that we did not pre-specify any of these analyses and the large number of tests we ran, we consider these results as exploratory and suggestive evidence for future studies. Across all our models, we estimate standard errors clustered at the school-level.

D. Coarsened Exact Matching

We complement our primary experimental analyses with non-parametric matching estimates of the effect of receiving free access to SchoolCNXT with at least basic user supports relative to not having access to SchoolCNXT at all. Given the large pool of schools that did not participate in our experimental trial, our data are particularly well suited to Coarsened Exact Matching.[14] We match participating schools based on eight observable characteristics that include school type, a measure based on the NYC school quality report, student enrollment, previous year absenteeism, and the percentage of students that are African American, Hispanic, English language learners, and FRPL eligible. We then estimate treatment effects using a

[13] Recent literature suggests the use of a negative binomial regression model over OLS when modelling over-dispersed count outcomes such as absences (Liu & Loeb, 2019).

[14] CEM reduces multivariate imbalance across treatment and comparison groups by binning observations based on multivariate coarsened data to find matching observations. Unlike many other matching methods, CEM reduces imbalance at all moments of the covariate distributions, not just the sample means (Iacus et al., 2012). We provide details about our matched comparison sample and a range of match statistics in Appendix E.

weighted least squares parameterization of Model 1 with weights provided by the CEM algorithm.[15]

VI. FINDINGS

A. School Communication Practices

Responses to our baseline administrator survey suggest that communication between schools and families is inefficient, fragmented, and unsystematic. The vast majority of administrators characterized both school-wide communication (87%) and individual teacher communication (75%) at their school as moderately effective or worse. As we show in Figure 1, administrators overwhelmingly reported that sending letters home with students and making phone calls home were the two primary methods of communicating with parents. Three out of four schools in our sample still relied on students to deliver written communication to parents. Teachers were most likely to make phone calls (92%) but used backpack letters as well (42%). These communication approaches have several limitations as backpack letters often don't reach parents, and phone calls can be ineffective due to outdated contact information and language barriers.

Administrators also reported that teachers predominantly contacted parents to alert them about students' struggles in school. As shown in Figure 2, the five most common reasons identified by administrators for why teachers communicate with parents were all about negative information: low academic performance, absences, inappropriate behavior, low student effort, and missing assignments. Administrators reported that teachers were substantially less likely to let parents know when students were doing well in school or putting forth strong effort. Almost

[15] Study schools that are unmatched receive a weight of zero while study schools that are matched receive a weight of one. Matched comparison schools receive a weight equal to the number of treatment schools divided by the number of comparison schools in a given stratum.

97% of administrators identified low academic performance as a reason teachers reached out, but only 43% said teachers did the same for high academic performance. Similarly, 63% of administrators reported teachers communicated with parents about low student effort, but only 28% reached out about high student effort. About half of the administrators perceived that teachers proactively reached out to parents to provide more neutral information about classroom events and assignments.

B. SchoolCNXT Take-up in the Control Group

Although mobile communication apps address many of the limitations presented by traditional communication methods, we find that SchoolCNXT was not widely adopted in participating schools. Administrators at 10 of the 132 schools that volunteered for the study did not even register the free SchoolCNXT accounts for their staffs. Among the 122 schools that created teacher accounts, Table 2 shows that 48% of staff members and 15% of parents in the control group had activated them by end of the 2016-17 school year. [16] As shown in Figure 3, staff activation rates varied considerably with nearly 1-in-4 schools with rates lower than 30% and about 1-in-3 schools with rates above 60%. Despite higher activation levels for staff in some schools, parent use remained persistently low at the overwhelming majority of schools. In 7-in-10 schools less than 20% of parents activated their accounts, while only 1-in-20 schools had parent activation rates greater than 40%.

Along the intensive margin, average usage rates also remained low in the control group. Less than one out of eight staff members and one out of twenty parents in the control group used the app to send a message or post, click-on, like, or save a news item. The average number of

[16] These rates are likely biased downward to some degree because SchoolCNXT auto-generated accounts based on district employment and enrollment records from the prior year, which included some educators and students who had moved schools or left the district altogether.

user interactions with the app was 2.7 for staff and 0.6 for parents in the control group. However, these low overall usage rates mask considerable variation in how frequently staff and parents used SchoolCNXT. Figure 4 depicts school-level total usage rates per student, pooling across staff and parents. It shows that nearly 7-in-10 schools logged less than one action per student, while a small minority conducted upwards of five actions per student.

C. The Effect of Intensive Supplemental Supports on Activation and Use

We present formal estimates of treatment effects in Table 3. Focusing on our preferred models with controls, we find that intensive supports increased the likelihood staff activated their accounts by a significant 7.0 percentage points, a 15% increase on the control group mean of 48%. We also find that the additional supports had a marginally significant effect on parents' activation rates, increasing activation by 3.2 percentage points relative to a control group mean of 15 percent, a 21% increase.

Overall, we find that intensive supports were successful at driving increased use of the SchoolCNXT app to communicate with parents. We begin by illustrating the effect of intensive user supports graphically by plotting usage rates across the school year in Figure 5. The intensive supports lead to consistently higher use of the app among both teachers and parents. This figure illustrates a steady increase in app use among users in the treatment group through April with a gradual decline at the end of the academic year. In contrast, total usage patterns in control-group schools are highest in the first months of the fall semester and slowly decline throughout the rest of the school year. The sharp, temporary declines in app use across treatment and control groups shown in Figure 5 correspond with school breaks.

We also find that supports and regular encouragement to communicate frequently with parents via the app caused staff in treatment schools to use the app at twice the rate of their peers

in control schools, a marginally significant effect. This makes sense given that total staff usage in the treatment group over the course of the year is almost twice that of educators in the control group (19,816 vs. 11,578 incidents of use). The increase in overall app use among staff in treatment schools appears to be driven primarily by news engagements which increased 2.5 fold (95% CI: 1.1, 5.9). Our point estimate for messages sent suggests a more modest increase of 1.5 times the rate of control group staff, which is not statistically significant (95% CI: 0.7, 3.3).[17] Treatment also led parents to proactively use the app twice as much as parents in control schools. This increase in overall app use was driven almost exclusively by increased parent engagement with news items. We find a near zero estimate (incident rate ratio close to one) of the treatment effect on messages sent.

We run a range of exploratory tests for heterogeneous treatment effects on activation and usage across staff and school characteristics.[18] Here we highlight a few patterns evident in the result shown in Table 4. We find suggestive patterns of larger treatment effects on both activation and use among administrators relative to teachers, but our estimates are relatively imprecise. We also find that intensive supports were more effective among schools rated as lower quality and schools serving larger populations of student of color (i.e. activation and usage declined in schools with large percentages of white students). Finally, our point estimates suggest that treatment was less effective at getting elementary school staff to activate their accounts relative to treated middle and high school staff. However, we find the opposite along

[17] We provide estimates where the 10 schools that dropped are recorded with imputed zero values for teacher and parent accounts in Appendix Table F1. We find that our results are quite robust across estimation approaches.
[18] We are able to identify a school users' staff type for 65% of SchoolCNXT school staff accounts. This match rate is in part due to schools' creating custom staff-side accounts for parent coordinators, security guards, afterschool staff, and other auxiliary staff.

the intensive margin of app use. Treatment caused elementary school staff with activated accounts to use the app considerably more than treated peers in middle and high schools.

D. The Effect of Intensive Supplemental Supports on Perceived Communication Quality

Although the treatment was successful at promoting increased app usage, we find little evidence the intensive supports improved the perceived quality of teacher-parent communication. We find no significant effects on communication quality as judged by administrators, teachers, or parents.[19] As we report in Table 5, estimates suggest that treatment increased the proportional odds that administrators rated the effectiveness of school-wide and individual teachers' communication as more effective by 52% and 53%, respectively, but these estimates are not significant (CI: 0.66, 3.48; 0.64, 3.70). Effects on our continuous standardized measures of staff and parent perceptions about communication quality are negatively signed and insignificant. Unfortunately, these estimates lack the precision necessary to rule out small to moderate (negative or positive) effects. Tests for heterogeneity in treatment effects on perceived communication quality across school characteristics presented in Table 6 reveal very few differences or consistent patterns.

E. Testing Explanations for Null Effects

Follow-up Year: SchoolCNXT continued to provide free access and basic supports to all 122 schools that participated in the study in the following academic year but stopped intensive supports for treatment schools. It is possible that schools required a year of experience with the new communication medium before adopting a more coordinated school-wide effort to use it. In fact, we find considerable declines in activation rates in the following year for both staff –

[19] While we find that schools which return an administrator survey are balanced on observables across the treatment condition, we remind readers that only 68% (n=90) of experimental schools (45 treatment and 45 control schools) returned end-of-year administrator surveys.

dropping from 48% to 43% activated – and parents – dropping from 16% to 10% percent (see Table 7). Conditional on activation, only half as many staff and parents used the app to send a message or like, save, or post a news item in the second year. In the experimental year, 1,152 staff members used the app at least once for a total of 31,394 instances of use. In the follow-up year, these numbers declined to 514 staff members using the app at least once for a total of 26,773 instances of use. We also find little evidence that usage instead became more concentrated among a minority of schools. The distribution of school usage rates per student in the follow up year shown in Figure 6 is strikingly similar to the distribution from the initial year (Figure 4), however, with a four-fold increase in the percentage of schools not using the app at all.

We display usage rates across the follow-up year by treatment and control in Figure 7. Interestingly, usage rates among educators remained higher in the treatment group through the fall semester, but then started to converge with the control group for the remainder of the school year. Without proactive support and regular encouragement to use the app, app use for staff in treatment schools declined from nearly 2.5 times the rate of control staff during the spring of the treatment year to only 1.4 times as much the following spring. However, the positive gap in usage rates among parents of students in treatment schools compared to control schools remained relatively constant across the follow-up academic year.[20]

Larger Treatment Contrast: It is possible that the null effects on perceptions of communication quality from the supplemental supports reflect the limited intensity of the treatment. We explore whether a more pronounced treatment – free access to SchoolCNXT with at least basic supports – might have affected these outcomes using our CEM approach. As we

[20] As shown in Appendix Table I1, we find no significant effects on activation rates in the second year, while effects on total usage for both staff and parents persisted in the follow-up year.

report in Table 8, we find some evidence to suggest this combined treatment resulted in measurable changes in communication quality. We estimate that providing free access to SchoolCNXT and at least basic supports improved teachers' perceptions of communication quality at their school by 0.16 standard deviations (95% CI: 0.02, 0.30). However, we do not find corresponding effects on parents' perceptions of communication quality.

F. The Effect of Intensive Supplemental Supports on Student Outcomes

We find no treatment effects of providing intensive supports on students' standardized achievement or absenteeism, with relatively precise zeros across our several specifications. We can rule out effects as small as 0.1 standard deviation in math and 0.03 SD in ELA, as well as changes in absence rates of relatively small magnitude (95% CI: 0.91 to 1.12 incident rate ratio). Estimates of the broader effect of providing free access to SchoolCNXT on student achievement and student absenteeism from our CEM models are also very small in magnitude and insignificant. Examining the effects of providing free access to SchoolCNXT with and without intensive supports separately or with lagged outcomes as controls produces similar statistically insignificant estimates. We provide full estimation details and results in Appendix Tables J1, K1, and L1. These findings are unsurprising given the low levels of overall app usage among schools that participated in the study.

VII. INSIDE THE BLACK BOX OF TEACHER-PARENT COMMUNICATION VIA MOBILE APPS

A. *Who Used the App?*

As described above, we find large variation in usage rates across staff and schools. Here we explore what predicts this variation to inform future efforts to maximize the potential of mobile communication apps. In Table 9, we explore with both bivariate and multivariate

negative binomial models how the characteristics of individual staff members might explain the variation in app use conditional on school characteristics. Administrators were primarily using the app to post and engage with general news items while teachers used the personalized messaging feature more regularly. School psychologists, social workers, guidance counselors, and administrative assistants used the app far less frequently.

We also find that less experienced staff used the app substantially more than their more experienced peers. For example, we find that novice staff with 0 to 3 years of experience used the app over 5 times as much as veterans with 15 or more years of experience. Female staff working in similar schools as males used the app more than 1.5 times as often, while Hispanic staff used the app meaningfully less than their white peers in similar schools.

In Table 10, we report results from models predicting total usage for staff and parents as a function of school characteristics. These results illustrate that, among our participating schools, teachers and parents in middle and high schools were substantially lower users of the app, using it between 3 to 4 times less than staff and parents in elementary schools (the omitted category). Staff and parents in schools with larger populations of students with disabilities tended to use the app slightly more often. We also find evidence that staff in schools serving larger populations of students that are English language learners and low-income families used the app more frequently. In contrast, staff in schools with larger populations of African American students and students that were absent more often in the prior year used it less frequently. These patterns suggest the potential to leverage the tool more effectively in secondary schools where student truancy is a challenge as well as in schools that serve higher percentages of African American students.

B. When Did Staff and Parents Use the App?

We find that staff and parent app use corresponded closely and followed similar patterns throughout the day, week, and academic year. As seen in Figure 8, both groups showed increasing usage throughout the afternoon with staff use peaking around the end of the school day between 3 and 4 pm and parent use peaking in the evening between 7 and 8 pm. Use among both staff and parents drops off precipitously after 7 pm and is quiet throughout the night before picking back up again in the morning. Staff and parent usage across the week tracked each other closely and dropped off substantially during the weekend. The similar patterns of usage across staff and parents illustrate the interactive nature of the communication app where a news post or message sent by a staff member prompts parent engagement and vice versa.

One limiting factor to teacher take-up might stem from reluctance to engage in parent communication activities outside of traditional work hours. Another factor might be simply that using the app more often creates more work for staff because they have to respond to more parent replies and inquiries. Schools might further maximize staff usage if they provided more dedicated time for communication during the contractual school day rather than expecting staff to correspond with parents during the evening.

C. What Did Staff and Parents Communicate About?

We explore the content of SchoolCNXT communications by coding a random sample of 100 news posts and 200 messages between staff and parents. We find that engagement with news posts was the preferred method of use among administrators. They commonly published to group posting boards to engage parents and inform them of general updates and events.[21] As seen in Figure 9, news items mostly provided encouragement to parents to engage with their children about schooling or to attend school events such as parent-teacher conferences and coffee with the

[21] We randomly sampled 100 news items and labeled them using a set of 11 non-mutually exclusive labels that emerged through iterative coding of the messages.

principal, for example, "*The children in grades k-2 will have a visit from the Junior Achievement High School Hero program this Friday! The program takes place in individual classrooms and usually is lots of fun. Ask your child about it on Friday!*" Teachers, who communicated through news posts far less often, used this feature to disseminate administrative class level information, for example, "*The chapter 3 math test will be on Monday, November 14. I have not received all the chapter 1 math tests signed. If you have not seen the first test, please ask your student and return it.*"

The messaging feature in SchoolCNXT was primarily used by teachers to communicate individually with parents about a range of topics. Entire conversation histories were generally short (median of 2 messages) and composed of messages that were about the length of a text (median of 62 characters). A random sample reveals that 9-in-10 conversations were between teachers and parents and 3-in-4 were one-to-one rather than group chats.[22] Interestingly, parents initiated the most conversations (53%), followed by teachers (40%) and then administrators (7%). Parents' proactive use of the communication app suggests a real demand for more information from schools. As shown in Figure 10, there was a wide range of topics represented in the conversations we coded from the messaging feature of the app. We identified 19 conversation topics with the most common topic, class content, only present in 11% of the messages.[23] For example, parents sent messages asking for advice about helping their students such as, "*Good Morning [teacher name], I'm [parent name]. How are you doing? [student*

[22] Messages are stored as entire conversation histories, which we subdivided by months. Next, we randomly selected 200 conversation-months and identified the start to the first conversation in each month. We then labeled messages that started conversations using a set of 19 non-mutually exclusive labels that emerged through iterative coding of the messages.

[23] Some notes on a few topics: *Student health* does not include sick notes such as "my student isn't feeling well…", rather student health refers to conversation about student mental health or visits to the counselor. *Parent engagement* is soliciting some specific parent action such as chaperoning a trip or practicing content with a child. *Specific assignment* and *class content* are not double-coded as some conversations are exclusively about a specific assignment such as due date whereas class content includes conversation about curricula.

name] doesn't really understand his assignment and I was wondering can you give me some insight on how to assist him with it? thank you so much it would be appreciated." Teachers sent messages to update parents on the progress of individual students such as, "*I just wanted to let you know that [student name] is trying very hard to make the improvements that we spoke about. I have let him know that I have observed his efforts and am very proud of him. Let's keep up the good work! Thank you for helping with this at home as well*."

In contrast to administrators' perceptions that teachers communicated most frequently about negative student issues, only a small fraction of messages (9%) focused on negative aspects of student performance, attendance, behavior, or effort. It appears staff primarily took advantage of the SchoolCNXT app to request or provide information that was more neutral (72%) or positive (19%) in content. These more neutral, day-to-day exchanges often included things like tracking down paperwork or permission slips, notifying parents of missed assignments, and excusing student absences.

VI. DISCUSSION AND CONCLUSION

Schools' fragmented approaches to communicating require parents to navigate a wide array of communication channels such as school websites, email updates, phone calls home, and backpack letters. Early web-based technologies like email and online gradebooks expanded the information available to parents. More recent advances in technology now provide a range of new mediums for consolidating communication methods and better engaging parents in student learning through improved communication and coordination between schools and families. However, our findings suggest that simply making these new technologies available to schools and teachers is unlikely to lead to widespread improvements in communication, even when paired with dedicated support and regular reminders to use these tools.

Our experimental results suggest that intensive user supports to schools can modestly increase usage but were not sufficient to overcome other adaptive challenges to high-quality communication. For example, our exploratory analyses show that mid- to late-career staff members were far less likely to use the app. Anecdotal evidence from interactions between SchoolCNXT support coordinators and schools suggests many older teachers found the mobile app unfamiliar and intimidating. More targeted and individualized support are likely critical for helping older teachers become comfortable and proficient with new communication technology. Another possibility is that veteran teachers had already developed communication practices that worked for them whereas less experienced teachers were more willing to try new practices.

Many teachers also expressed uncertainty during trainings about what they should communicate about. As a result, in-app text exchanges often focused narrowly on coordinating logistics or providing reminders rather than on students' academic and social-emotional development. This is a far cry from more promising types of communication such as sharing encouraging information about what students are doing well, soliciting parents' ideas and support for providing a productive learning environment at home, and making specific, actionable suggestions about what students can do to improve (Kraft & Rogers, 2015).

Anecdotal and descriptive evidence also suggest the low and inconsistent take-up of the mobile app was due, in part, to administrators' failure to establish school-wide expectations about adopting a common communication platform and set of communication practices. SchoolCNXT support coordinators observed that the presence and demeanor of administrators at on-site training sessions sent an important signal to teachers about an expectation of use or if the tool was worthwhile. Provision of these tools without clear expectations for standardizing communication approaches may even further complicate matters for parents. After a year of free

access to the app, 75% of administrators reported teachers in their schools used multiple, different communication apps for contacting home and 15% of administrators reported the use of at least four different communication apps (e.g. ClassDojo, Facebook, Remind, Class Messenger, PupilPath, Edmodo). Teachers clearly were still making independent, uncoordinated decisions about how to communicate with parents.

From a policy perspective, our findings provide a cautionary tale for those hoping "EdTech" solutions will be a silver bullet for persistent challenges in the education sector. Our findings highlight the obstacles to promoting successful adoption of new education technology even with intensive user supports. The mobile communication app we studied was only used by a small fraction of staff members despite demand from parents for better communication options and the self-selected nature of our sample where leaders proactively volunteered for the opportunity to use SchoolCNXT. Low overall levels of parent engagement with the app likely reflect low staff usage and the fact that the intensive supports targeted school staff rather than parents. Importantly, we found that parents were more likely than teachers to initiate individualized messages when they had the opportunity to do so.

Improving the frequency and quality of communication likely requires school-wide organizational practices that are communicated clearly, commonly understood, and consistently applied. Schools that used the app the most made it their default communication medium for all internal and external communications, while some even tracked staff attendance at professional development through the tool. Administrators, teachers, and auxiliary staff members in these schools consistently encouraged parents and students to refer to SchoolCNXT for important class updates and to complete administrative processes. While best practices may differ across schools, key aspects of developing healthy lines of communication between schools and parents

include identifying a single common platform for all staff to use, setting clear expectations about the frequency of communication with families, fostering transparency around how much teachers are communicating, providing ongoing professional development about best practices, and creating dedicated time for teachers to connect with parents during the work day.

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Figures

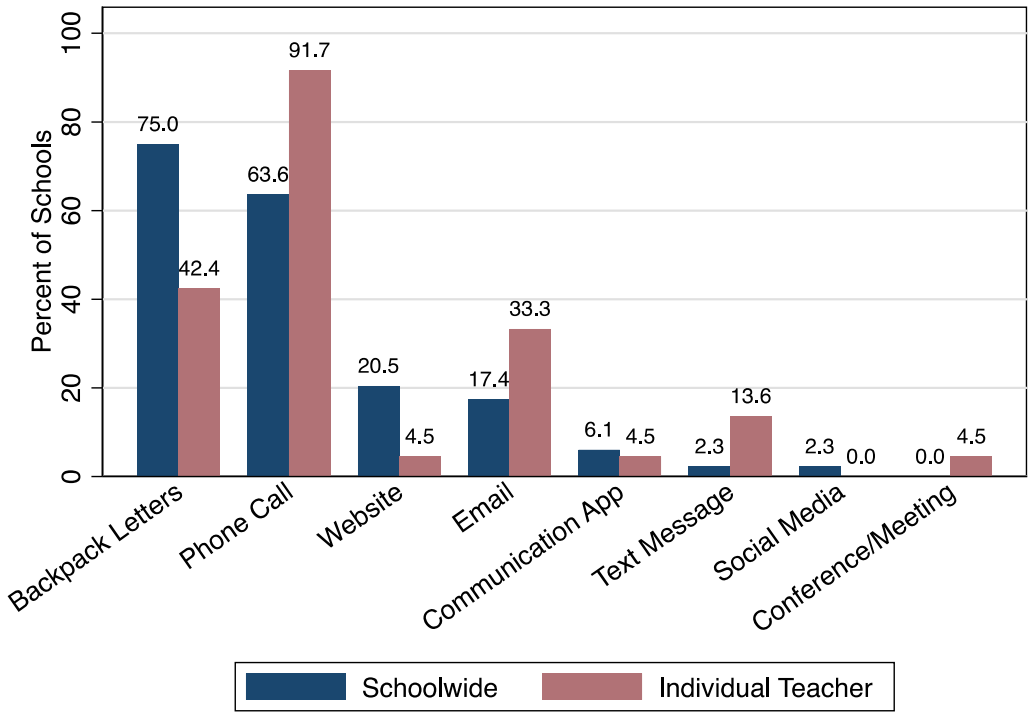


Figure 1: Top two methods used to contact home for school-wide and individual teacher communication with home according to administrators, *n(school)=132*

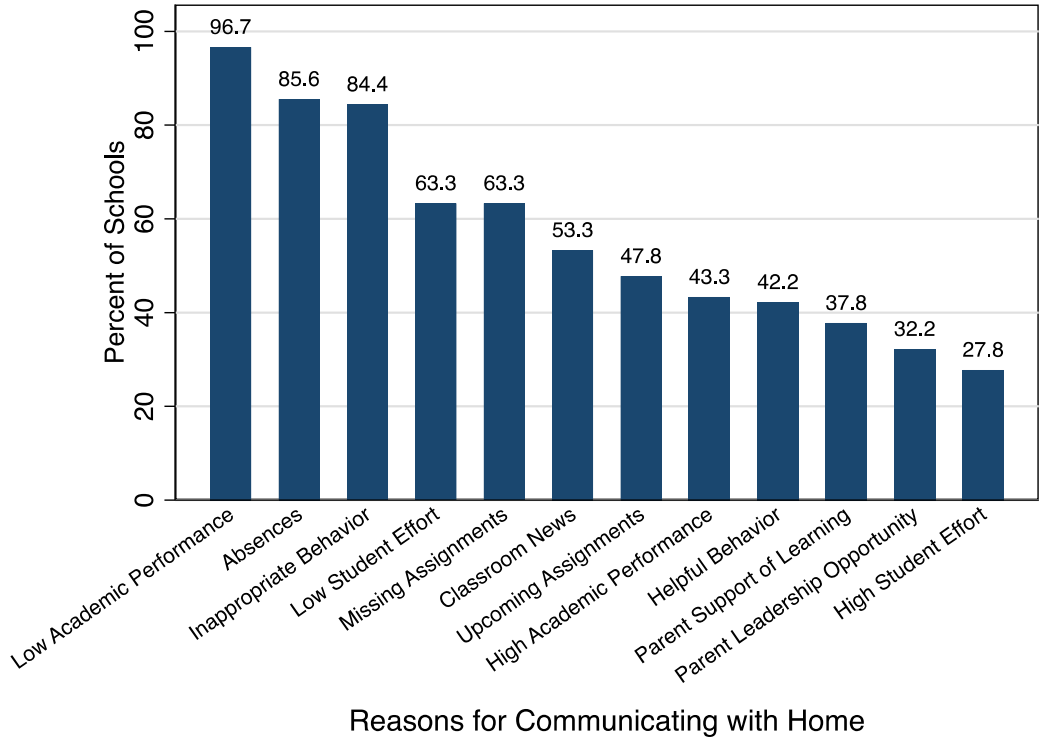
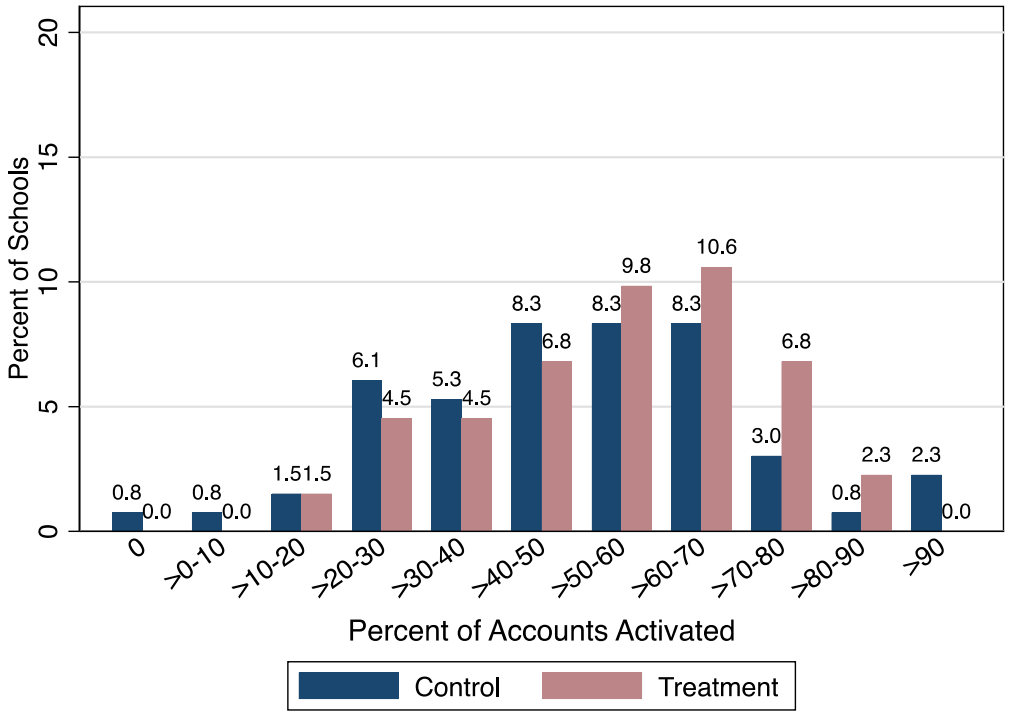
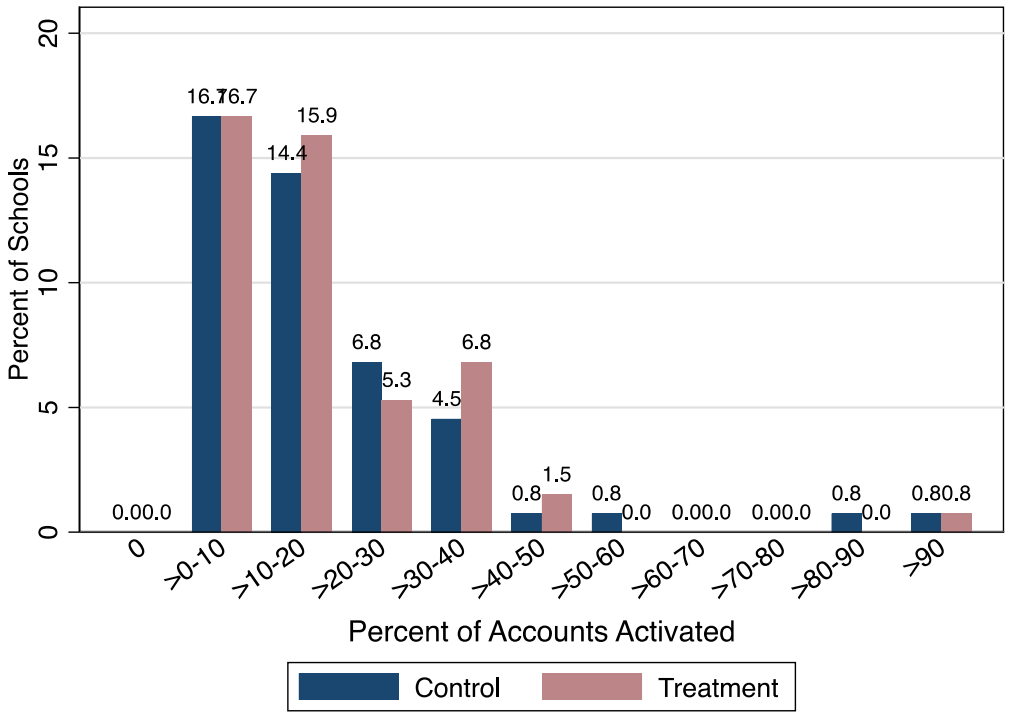


Figure 2: Primary reasons that teachers contact home as identified by administrators, *n(school)=90*



Panel A: School staff, n(school staff)=8,399



Panel B: Parents, n(parent)=91,317

Figure 3: Percent of school staff (Panel A) and parents (Panel B) activating their accounts by treatment in 2016-17

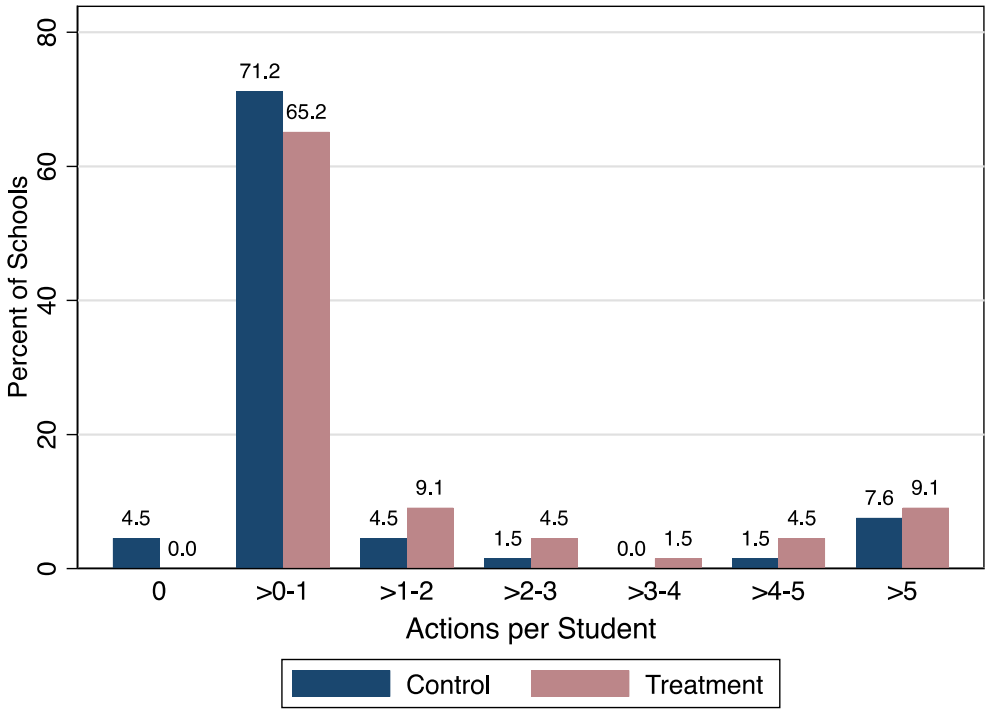
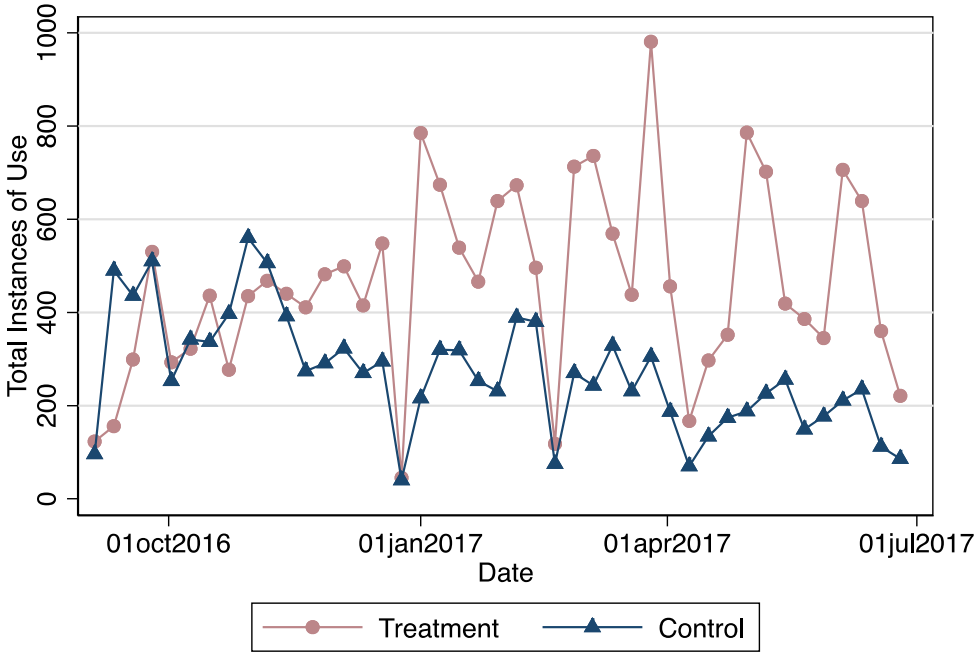
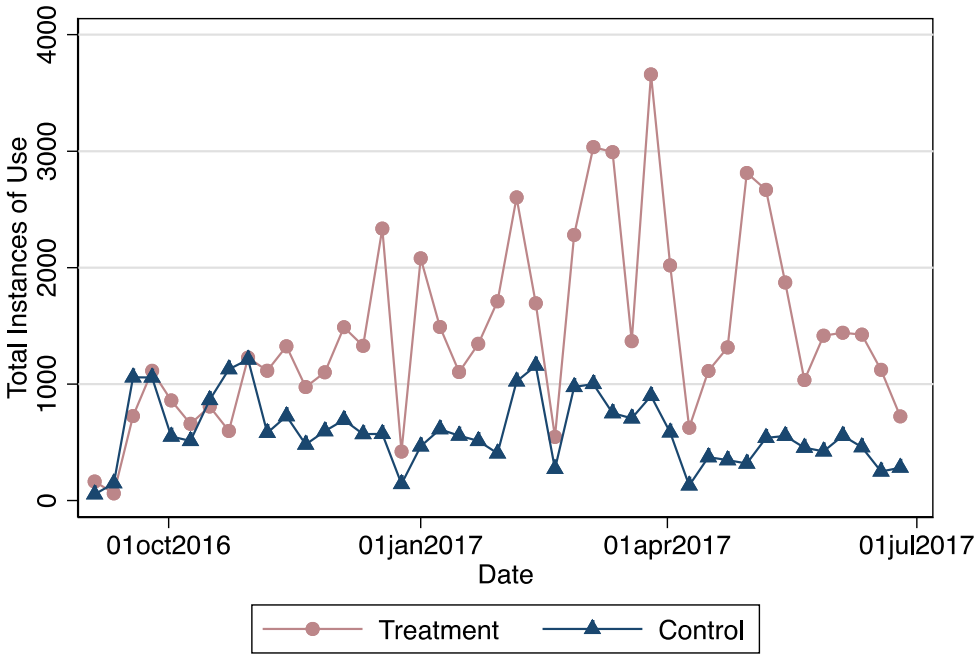


Figure 4: Percent of schools with a given number of average instances of app use per student by treatment in 2016-17, *n(total actions)=118,761*



Panel A: School staff



Panel B: Parents

Figure 5: Weekly binned total app use over the school year by treatment for school staff (panel A) and parents (panel B) in 2016-17

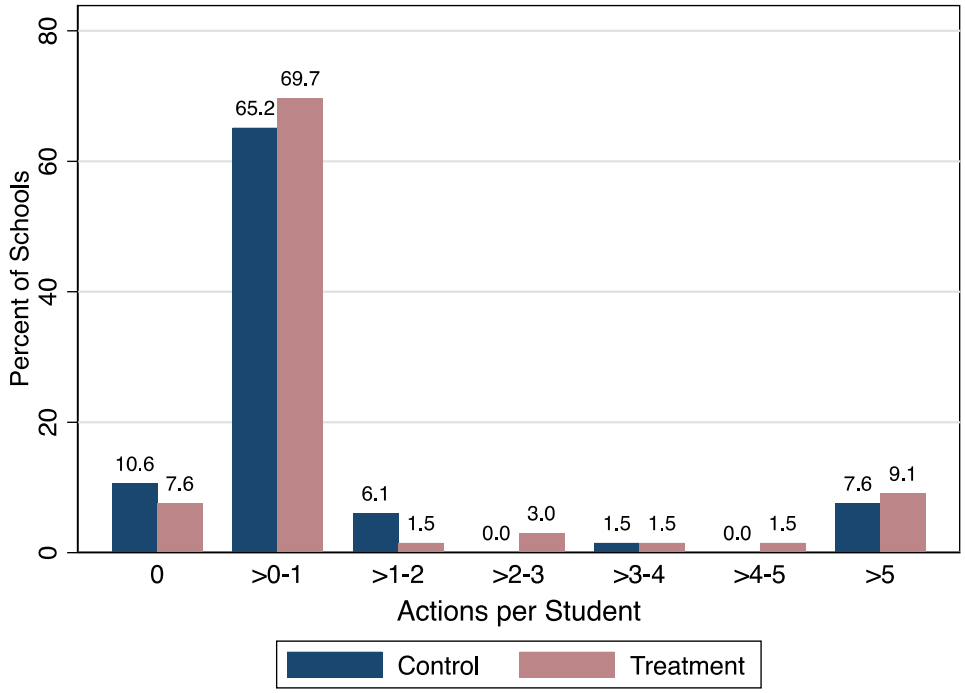
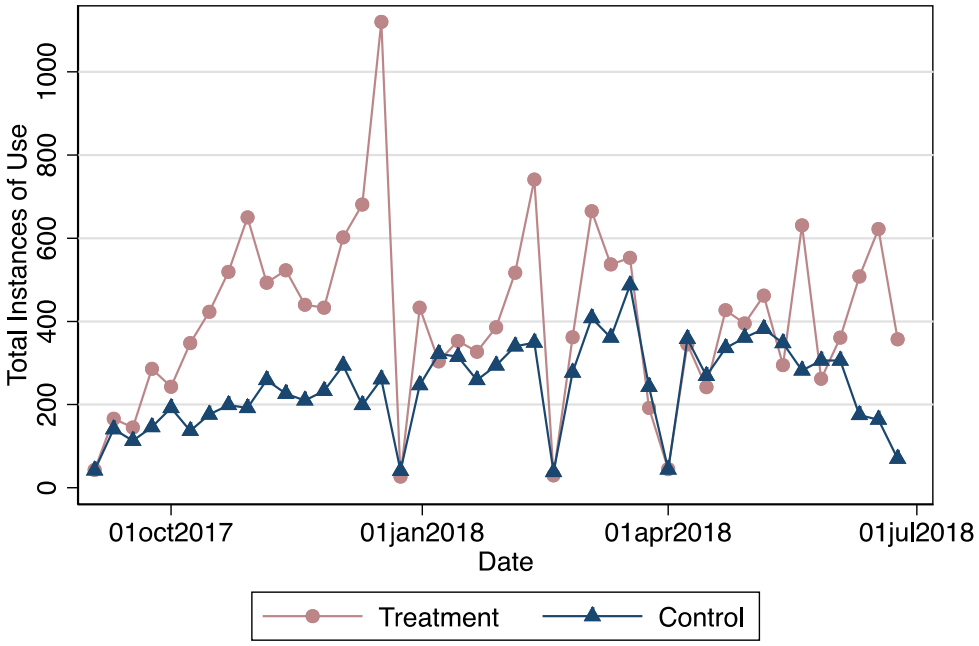
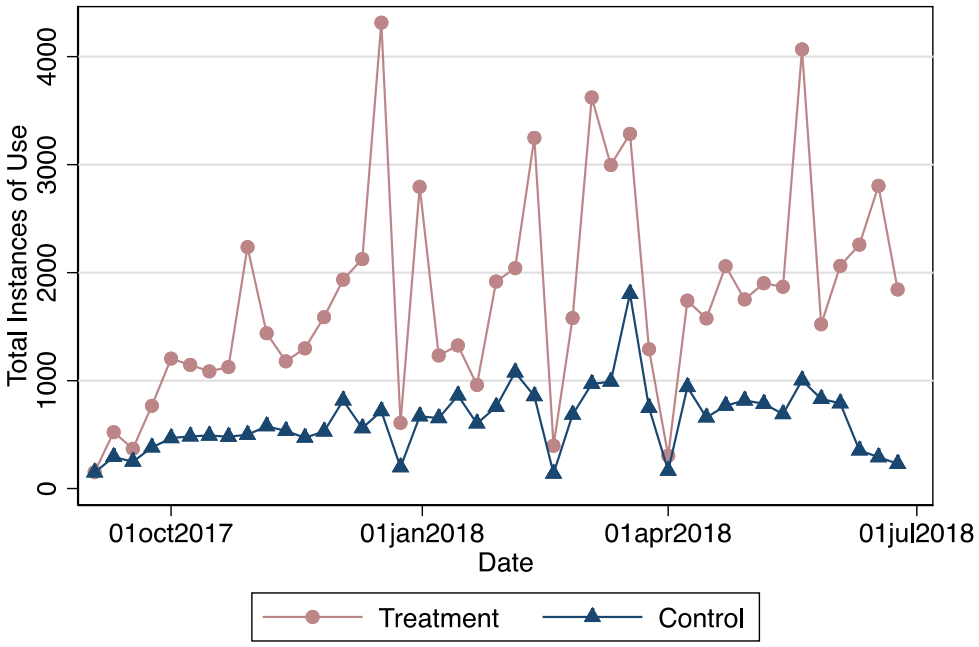


Figure 6: Percent of schools with a given number of average instances of app use per student by treatment in the follow-up year, 2017-18, *n(actions)=113,754*



Panel A: School staff



Panel B: Teachers

Figure 7: Weekly binned total app use over the school year by treatment for school staff (panel A) and parents (panel B) in the follow-up year, 2017-18

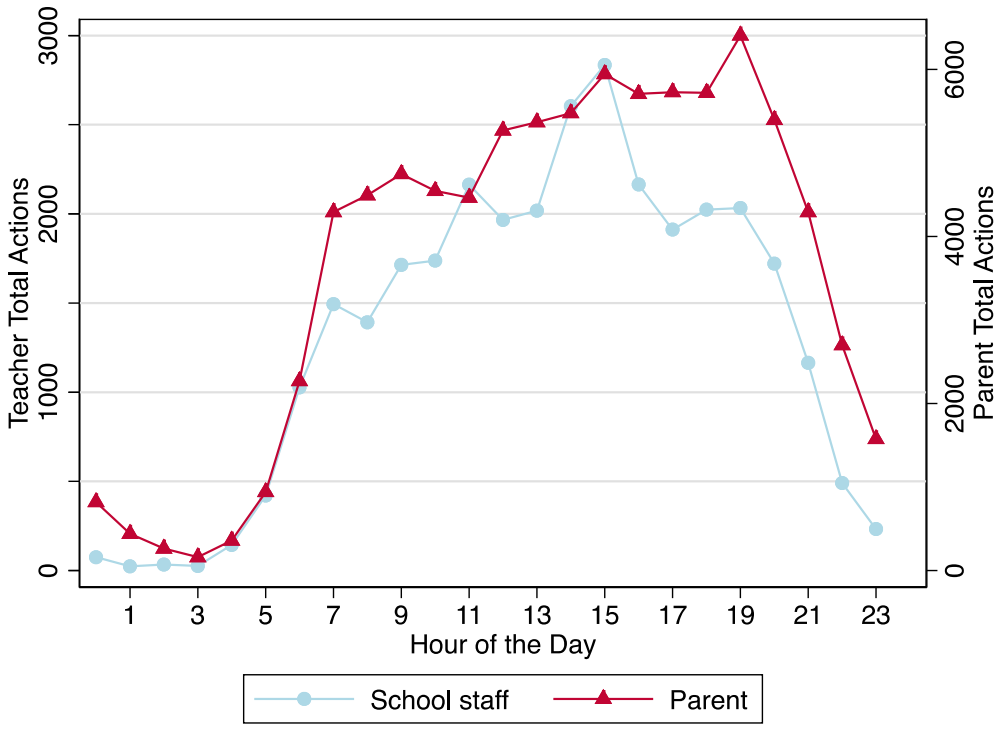


Figure 8: Total actions by hour of the day for school staff and parents in 2016-17

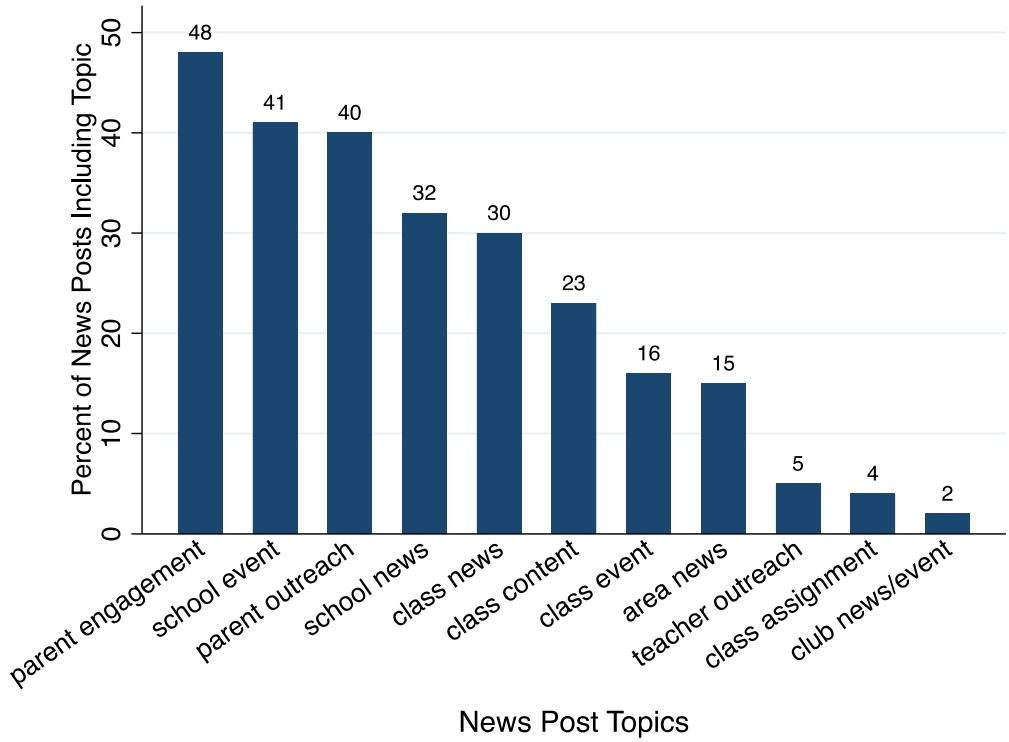


Figure 9: Percent of 100 randomly sampled news posts containing a given topic in 2016-17, *n(news posts)=100*

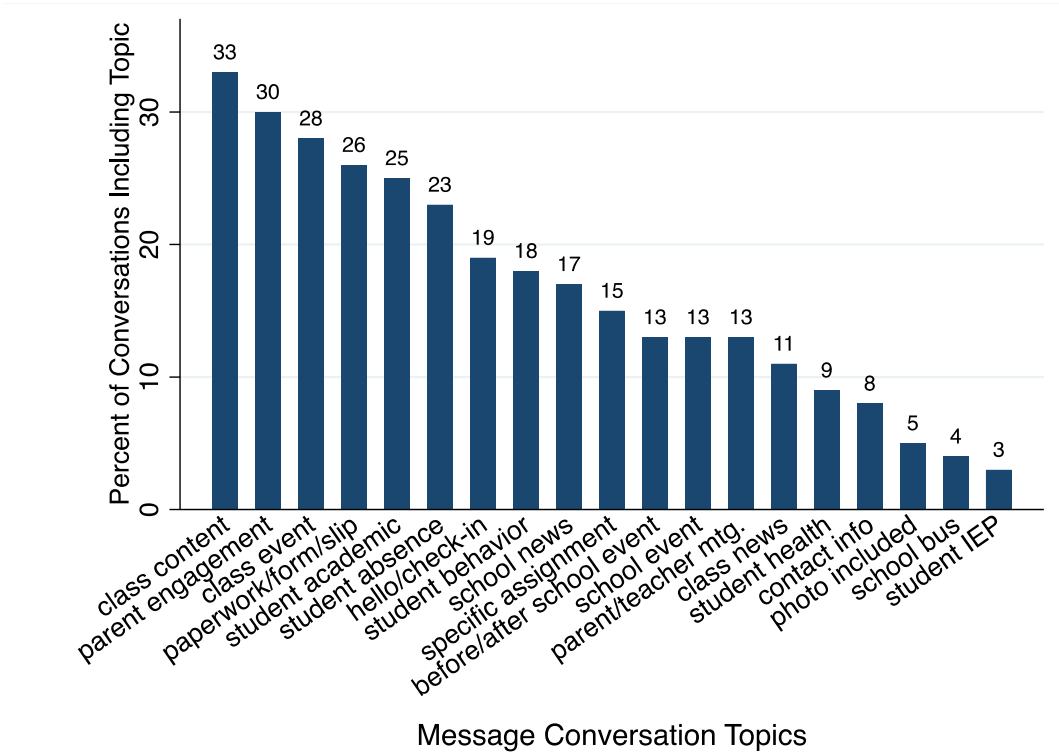


Figure 10: Percent of 200 randomly sampled direct message conversations containing a given topic in 2016-17, *n(conversation-months)=200*

Tables

Table 1. Baseline School and Teacher Characteristics, 2015-16

	District sample	Experimental sample			
		Full	Control	Treatment	T vs C
School level outcomes					
School quality score	-0.01	0.02	0.01	0.02	0.97
Math achievement	0.05	-0.08	-0.10	-0.06	0.73
ELA achievement	0.10	-0.07	-0.04	-0.11	0.57
Days absent	14.76	14.88	14.67	15.08	0.74
School level characteristics					
School type					
Special needs	38	4	2	2	1.00
Early childhood	18	4	2	2	1.00
K–8	544	8	4	4	1.00
Elementary	337	62	31	31	1.00
Middle	133	13	6	7	0.77
High	254	41	21	20	0.85
SWD (%)	19.81	22.25	22.41	22.09	0.89
ELL (%)	14.13	16.16	15.61	16.71	0.68
Male (%)	51.41	51.39	50.61	52.16	0.29
FRPL (%)	73.44	79.50	79.98	79.02	0.72
Race (%)					
African American	29.83	32.31	31.05	33.57	0.60
Asian	12.37	13.55	13.91	13.19	0.84
Hispanic	42.16	44.29	45.41	43.18	0.62
other	2.12	1.86	1.71	2.00	0.49
white	13.52	7.99	7.92	8.06	0.95
Teacher level characteristics					
Teacher annual salary	78174	77495	76976	78015	0.35
Female (%)	78.11	79.76	79.45	80.07	0.81
Race (%)					
African American	21.28	21.62	18.77	24.47	0.12
Asian	5.81	8.24	8.68	7.80	0.65
Hispanic	17.09	18.24	18.86	17.62	0.65
other	1.89	2.06	2.11	2.02	0.83
white	53.94	49.83	51.58	48.08	0.38
n(School)	1,286	132	66	66	

Notes. We construct the school quality measure from a principal components analysis of the annual NYC DOE School Quality Reports from the previous year. Student achievement measures in math and ELA are based on New York State Assessments. We use scores from students' first time taking a test in a given year and standardize them in a given subject and grade to be mean-zero and have unit-variance before averaging standardized scores at the school level in each subject. With the exception of school quality score, achievement in math and ELA, days absent, school type, and teacher annual salary, all values are percents from 0-100. Teacher annual salary is reported in dollars. Special needs schools refer to schools in the NYC district that specifically serve students with disabilities. SWD refers to students with disabilities; ELL refers to English language learning students; FRPL refers to students receiving free or reduced price lunch. The "T vs. C" column reports the p-value for the null hypothesis that the treatment (T) and control (C) distributions are significantly different from one another for a given covariate.

Table 2. Overall Activation Rates and In-App Actions by Treatment, 2016-17

	Overall		Per User Totals		
	Activated	Used at least once	Total use	Messages sent	News Engagements
	Panel A: School Staff				
Control	48%	12%	2.73	1.51	1.22
Treatment	56%	16%	4.76	1.98	2.78
Total	52%	14%	3.74	1.74	1.99
n(School Staff)			8,399		
	Panel B: Parents				
Control	15%	5%	0.57	0.18	0.39
Treatment	18%	7%	1.33	0.18	1.15
Total	16%	6%	0.96	0.18	0.78
n(Parent)			91,317		

Notes. These statistics are based on the 122 school sample that successfully registered for SchoolCNXT

Table 3. The Effect of Intensive User Supports on App Activation and Usage, 2016-17

Model Type	Linear Probability Model		Negative Binomial					
Panel A: School Staff								
	Activation rate		Total use		Messages sent		News engagements	
Treat	0.077*	0.070**	1.741	2.500**	1.311	1.883*	2.272	3.311***
	(0.042)	(0.034)	[1.205]	[2.349]	[0.652]	[1.655]	[1.475]	[2.848]
Control mean	0.48		2.73		1.51		1.22	
Control total			11,578		6,399		5,179	
n(Staff) / n(School)			8,399 / 122					
Panel B: Parents								
	Activation rate		Total use		Messages sent		News engagements	
Treat	0.029	0.032*	2.335*	2.437**	1.009	1.123	2.930**	3.145***
	(0.025)	(0.019)	[1.778]	[2.330]	[0.021]	[0.358]	[1.978]	[2.678]
Control mean	0.15		0.57		0.18		0.39	
Control total			25,563		7,914		17,649	
n(Parent) / n(School)			91,317 / 122					
Controls	Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. These estimates are from a sample that does not assign zeros for activation and usage outcomes in schools that did not register; instead those schools receive a missing value for these estimates. Linear probability model coefficients are reported for Activation rate. Incident rate ratios reported for all other outcomes. Standard errors are clustered at the school level and reported in parenthesis and t-statistics are in brackets. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male.

Table 4. Heterogeneous Effects of Intensive User Supports on App Use among School Staff and Parents

Model Type		Linear Probability Model		Negative Binomial		
		Panel A: School Staff				
	Omitted	Activation		Total Use		n(Staff)
Treat	Teacher	0.101*	0.092*	1.778	2.206*	5,509
		(0.057)	(0.049)	[1.274]	[1.864]	
Treat*SpEd teacher		-0.031	-0.015	0.936	0.524**	
		(0.036)	(0.036)	[-0.206]	[-2.130]	
Treat*Administrator		0.033	0.034	2.492*	2.536	
		(0.070)	(0.068)	[1.823]	[1.631]	
Treat*Counselor		-0.060	-0.063	0.869	0.403	
		(0.061)	(0.065)	[-0.163]	[-1.278]	
Treat*Tch. experience		0.003	0.002	1.092***	1.051***	5,505
		(0.002)	(0.002)	[3.693]	[3.069]	
Treat*Tch. female		-0.053	-0.023	0.932	1.337	5,504
		(0.049)	(0.045)	[-0.100]	[0.479]	
Treat*Pct. FRPL		-0.004	-0.004	0.932**	0.950*	8,399
		(0.003)	(0.003)	[-2.378]	[-1.833]	
Treat*Pct. ELL		0.000	-0.000	1.000	1.000	8,399
		(0.003)	(0.003)	[0.010]	[0.006]	
Treat*Pct. Asian		0.001	-0.001	1.010	0.984	8,399
		(0.002)	(0.001)	[0.540]	[-1.093]	
Treat*Pct. Afr. Am.		-0.001	-0.001	0.998	1.011	8,399
		(0.001)	(0.001)	[-0.083]	[0.647]	
Treat*Pct. Hispanic		0.001	0.002*	0.981	1.026	8,399
		(0.002)	(0.001)	[-1.080]	[1.125]	
Treat*Pct. white		-0.003	-0.006	0.998	0.900***	8,399
		(0.006)	(0.004)	[-0.061]	[-2.734]	
Treat	Elem.	0.008	0.018	1.714	2.215	8,399
		(0.055)	(0.055)	[1.136]	[1.565]	
Treat*Middle school		0.139	0.117	0.289	0.233*	
		(0.104)	(0.115)	[-1.217]	[-1.712]	
Treat*High school		0.122	0.080	0.639	0.315	
		(0.090)	(0.078)	[-0.470]	[-1.166]	
Treat*School quality		-0.005	-0.002	0.342***	0.504**	8,399
		(0.043)	(0.030)	[-2.628]	[-2.043]	
		Panel B: Parents				
	Omitted	Activation		Total Use		n(Parents)
Treat*Pct. FRPL		-0.001	-0.001	0.955	0.953*	91,317
		(0.002)	(0.002)	[-1.402]	[-1.933]	
Treat*Pct. ELL		0.001	0.000	1.004	1.009	91,317
		(0.002)	(0.001)	[0.146]	[0.377]	

Treat*Pct. Asian		-0.001	-0.001	1.021	1.006	91,317
		(0.001)	(0.001)	[1.231]	[0.350]	
Treat*Pct. Afr. Am.		-0.001	-0.000	0.994	1.002	91,317
		(0.001)	(0.001)	[-0.340]	[0.097]	
Treat*Pct. Hispanic		0.001	0.002**	0.983	1.003	91,317
		(0.001)	(0.001)	[-0.868]	[0.156]	
Treat*Pct. white		0.001	-0.002	0.984	0.931**	91,317
		(0.002)	(0.002)	[-0.463]	[-2.260]	
Treat	Elem.	0.029	0.048*	2.102	2.534*	91,317
		(0.032)	(0.028)	[1.536]	[1.769]	
Treat*Middle school		-0.063	-0.034	0.490	0.415	
		(0.096)	(0.083)	[-0.645]	[-0.894]	
Treat*High school		0.015	-0.030	1.676	0.486	
		(0.044)	(0.036)	[0.550]	[-0.857]	
Treat*School quality		-0.008	-0.002	0.449**	0.750	91,317
		(0.026)	(0.019)	[-2.036]	[-0.821]	
Controls			Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Each row represents a separate specification such that any given model includes the baseline treatment, the baseline covariate, and the treatment interacted with the covariate. In the case of categorical variables – school type and staff type – all types are included and middle school and regular teacher, respectively, are the omitted categories. Results for K-8, special needs, and early childhood schools not shown. The counselor category refers to school counselors, psychologists, and social workers. We use a linear probability model when estimating models with activation as the outcome of interest. For all other models we use a negative binomial and incident rate ratios are reported. Standard errors are clustered at the school level and reported in parenthesis and t-statistics are in brackets. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male. For models examining heterogeneity of treatment in terms school type and staff roles, the percentage of students who are African American and Hispanic are combined into a single control covariate.

Table 5. The Effect of Intensive User Supports on Administrator, Teacher, and Parent Perceptions of Communication Quality Between Schools and Home, 2016-17

Model type	Ordered Logistic				Ordinary Least Squares			
	Administrator perceptions				Teacher perceptions		Parent perceptions	
	School-wide		Individual					
Treatment	1.502	1.515	1.302	1.534	-0.064	-0.087	-0.023	-0.046
	[1.008]	[0.979]	[0.656]	[0.954]	(0.148)	(0.132)	(0.143)	(0.109)
n(Schools)	90				132			
n(Respondents)	90				4,970		34,598	
Controls	Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Administrator perceptions of school-wide and individual teacher communication effectiveness are measured by questions on the End of Year survey we administer. Teacher and parent perceptions are measured by a PCA on multiple questions from the NYC End of Year school survey for teachers and parents, respectively. Proportional odds ratios are reported for estimates of treatment effects on administrator perceptions. Standard errors are clustered at the school level and reported in parenthesis and t-statistics in brackets. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences, and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male. A lagged dependent variable is included as a control in specifications where teacher and parent perceptions are the outcome.

Table 6. Heterogeneous Effects of Intensive User Supports on Administrator, Teacher, and Parent Perceptions of Communication Quality Between Schools and Home, 2016-17

Model type		Ordered Logistic				Ordinary Least Squares			
		Administrator perceptions				Teacher perceptions		Parent perceptions	
	Omitted	School-wide		Individual					
Treat*Tch. experience		0.870	0.911	1.009	1.078	-0.011	0.002	0.001	-0.003
		[-1.231]	[-0.699]	[0.069]	[0.567]	(0.045)	(0.040)	(0.042)	(0.028)
Treat*Tch. female		0.938**	0.952	0.975	0.999	-0.003	0.007	0.003	0.010*
		[-2.407]	[-1.553]	[-0.962]	[-0.023]	(0.011)	(0.009)	(0.010)	(0.006)
Treat*Pct. FRPL		1.013	1.017	1.004	1.000	0.006	0.012*	-0.005	0.001
		[0.638]	[0.725]	[0.204]	[-0.002]	(0.007)	(0.007)	(0.008)	(0.005)
Treat*Pct. ELL		1.037	1.047	1.017	1.030	0.006	-0.001	0.001	-0.000
		[1.238]	[1.490]	[0.629]	[1.078]	(0.008)	(0.007)	(0.008)	(0.005)
Treat*Pct. Asian		1.026	1.034*	1.026	1.037	0.000	-0.005	0.010*	0.003
		[1.327]	[1.692]	[0.950]	[1.404]	(0.005)	(0.005)	(0.006)	(0.003)
Treat*Pct. Afr. Am.		0.975*	0.973*	0.979	0.974	-0.004	0.001	-0.006	-0.003
		[-1.771]	[-1.844]	[-1.473]	[-1.612]	(0.005)	(0.004)	(0.005)	(0.004)
Treat*Pct. Hispanic		1.000	1.001	0.995	0.995	0.004	0.004	-0.006	-0.001
		[0.021]	[0.079]	[-0.319]	[-0.268]	(0.005)	(0.004)	(0.006)	(0.004)
Treat*Pct. white		1.025	1.011	1.059*	1.054	-0.002	-0.006	0.026**	0.013*
		[0.851]	[0.304]	[1.922]	[1.379]	(0.008)	(0.007)	(0.010)	(0.008)
Treat	Elem.	0.645	0.774	1.055	1.592	-0.087	-0.015	-0.010	0.072
		[-0.782]	[-0.443]	[0.097]	[0.722]	(0.161)	(0.159)	(0.151)	(0.120)
Treat*Middle school		27.708**	29.448*	14.589*	5.522	0.134	0.217	0.243	0.136
		[1.964]	[1.724]	[1.786]	[1.283]	(0.425)	(0.388)	(0.470)	(0.358)
Treat*High school		5.442*	2.565	0.747	0.328	0.016	-0.319	-0.229	-0.539**
		[1.805]	[0.807]	[-0.290]	[-1.001]	(0.375)	(0.301)	(0.339)	(0.216)
Treat*School quality		1.481	1.650	0.830	0.861	0.215	0.221	0.130	0.154
		[1.191]	[1.171]	[-0.506]	[-0.380]	(0.162)	(0.136)	(0.148)	(0.109)
n(Schools)		90				132		132	

n(Respondents)	90	4,970	34,598	
Controls	Yes	Yes	Yes	Yes

Notes. * p<0.10, ** p<0.05, *** p<0.01. Each row represents a separate specification such that any given model includes the baseline treatment, the baseline covariate, and the treatment interacted with the covariate. In the case of categorical variables – school type and staff type – all types are included and middle school and regular teacher, respectively, are the omitted categories. Results for K-8, special needs, and early childhood schools not shown. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male.

Table 7. Overall Activation Rates and In-App Actions by Treatment, 2016-17

	Overall		Per User Totals		
	Activated	Used at least once	Total use	Messages sent	News Engagements
	Panel A: School Staff				
Control	40%	5%	2.41	1.22	1.19
Treatment	46%	7%	4.24	1.73	2.51
Total	43%	6%	3.30	1.47	1.83
n(School Staff)			8,105		
	Panel B: Parents				
Control	9%	2%	0.41	0.11	0.31
Treatment	10%	3%	1.05	0.13	0.92
Total	10%	2%	0.73	0.12	0.61
n(Parents)			119,388		

Notes. These statistics are based on the 122 school sample that successfully registered for SchoolCNXT

Table 8. The Joint and Disaggregated Effect of App Access and at least Basic User Supports on Perceptions of Communication Quality, 2016-17

Model Type	Weighted Least Squares							
	Teachers				Parents			
	Joint		Disaggregated		Joint		Disaggregated	
App w/ at least basic supports	0.096	0.164**			-0.006	0.008		
	(0.095)	(0.076)			(0.093)	(0.058)		
App w/ intensive supports			0.028	0.098			-0.046	-0.050
			(0.138)	(0.101)			(0.129)	(0.074)
App w/ basic supports			0.170	0.237**			0.039	0.072
			(0.111)	(0.100)			(0.114)	(0.078)
n(Total Schools)	753				748			
n(Experimental Schools)	111							
p-value of t-test for equivalence			0.389	0.296			0.216	0.670
Controls	Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Treatment refers to the full sample of schools that participated in our study. Standard errors are clustered at the school level and in parentheses. Control covariates include school type, student enrollment, a lagged school quality measure, lagged absences, and the percentage of students in a school that are African American, Hispanic, English language learners, FRPL eligible, and students with disabilities. Schools are matched based on school type and medial cuts of lagged average absences, a lagged school quality measure, student enrollment, and the percentage of students that are Hispanic, African American, ELL designated, and FRPL eligible. The CEM algorithm matched 111 of 122 study schools to 753 NYC comparison schools that did not participate in the study.

Table 9. The Relationship Between School Staff Characteristics and App Usage, 2016-17

Model Type		Negative Binomial					
		Total Use		Messages Sent		News Engagements	
	Omitted	Separate Models	Joint Model	Separate Models	Joint Model	Separate Models	Joint Model
School staff type	Teacher						
Administrator		1.990**	0.769	0.886	0.308*	4.483***	3.535**
		[2.058]	[-0.447]	[-0.401]	[-1.744]	[4.547]	[2.423]
SpEd Teacher		0.843	0.807	0.577***	0.553***	1.236	1.012
		[-1.088]	[-1.287]	[-2.708]	[-3.002]	[1.101]	[0.072]
Counselor		0.307***	0.210***	0.209***	0.160***	0.456***	0.273***
		[-3.853]	[-5.091]	[-4.915]	[-5.353]	[-3.071]	[-4.879]
Years of experience in DOE	15+						
0 - 3		1.810***	5.108***	1.756**	6.352***	1.684***	3.517***
		[2.829]	[3.460]	[2.183]	[3.278]	[2.989]	[3.243]
3.1 - 6		1.094	3.123***	0.675	2.517**	1.746**	3.451***
		[0.510]	[3.345]	[-1.467]	[2.278]	[2.037]	[4.115]
6.1 - 10		0.856	1.554*	0.711	1.521	1.076	1.626*
		[-0.705]	[1.697]	[-1.354]	[1.404]	[0.273]	[1.716]
10.1 - 15		1.434*	1.962***	1.275	1.934***	1.454*	1.625***
		[1.878]	[3.695]	[1.316]	[3.083]	[1.672]	[2.736]
Annual Salary in 1000s		1.000	1.000**	1.000	1.000**	1.000*	1.000
		[0.736]	[2.295]	[-0.183]	[2.255]	[1.873]	[1.404]
Female		1.314	1.664***	1.213	1.631*	1.641***	1.844***
		[1.100]	[2.735]	[0.588]	[1.895]	[3.698]	[3.876]
Race	white						
African American		0.824	0.832	0.820	0.716	0.892	0.989
		[-0.941]	[-0.986]	[-0.791]	[-1.476]	[-0.457]	[-0.059]
Asian		1.188	1.038	1.309	0.982	1.019	1.158
		[0.508]	[0.120]	[0.671]	[-0.051]	[0.054]	[0.456]
Hispanic		0.596**	0.622**	0.623*	0.638*	0.609***	0.642***
		[-2.512]	[-2.257]	[-1.749]	[-1.713]	[-3.258]	[-2.782]
n(Staff)				5,059			
School-level covariates		Yes	Yes	Yes	Yes	Yes	Yes

Notes. * p<0.10, ** p<0.05, *** p<0.01. Incident rate ratios are reported with t-statistics in brackets. Column 1 estimates are from a regression of the dependent variable on a single teacher-level covariate and all school level covariates. Column 2 estimates are from a regression of the dependent variable on all teacher and school-level covariates. The omitted category for experience in the DOE is teachers with more than 15 years of experience. The omitted category for school staff type is standard classroom teacher. The race covariates are from a single categorical variable with "white" as the omitted category. School level controls include school type, student-teacher ratio, student enrollment, lagged absenteeism, lagged school quality measure, and the percent of students that are male, Hispanic, African American, FRPL receiving, ELL, and SWD.

Table 10. The Relationship Between School Characteristics and App Usage, 2016-17

Model Type	Negative Binomial			
	School Staff		Parents	
	Total Use		Total Use	
	Separate Models	Joint Model	Separate Models	Joint Model
School type - Elem. Omitted				
Middle	0.186***	0.263***	0.213***	0.360**
	[-3.165]	[-2.808]	[-2.857]	[-2.058]
High	0.097***	0.185***	0.066***	0.229***
	[-4.811]	[-3.058]	[-4.944]	[-2.624]
Male (%)	0.952*	0.982	0.965	1.021
	[-1.741]	[-0.882]	[-0.893]	[0.986]
Hispanic (%)	1.006	0.997	1.004	1.003
	[0.526]	[-0.356]	[0.353]	[0.346]
African American (%)	0.966***	0.966***	0.965***	0.977**
	[-4.151]	[-3.530]	[-4.075]	[-2.016]
FRPL (%)	0.989	1.011	0.980	0.993
	[-0.627]	[0.706]	[-1.202]	[-0.401]
ELL (%)	1.023	1.018	1.014	1.012
	[1.516]	[1.427]	[1.060]	[0.906]
SWD (%)	0.979*	1.109***	0.994	1.083**
	[-1.804]	[2.951]	[-0.185]	[2.066]
Student-teacher ratio	0.818	1.122	0.667***	0.973
	[-1.387]	[1.029]	[-3.023]	[-0.228]
Student enrollment	0.999	0.998***	0.999	0.999***
	[-1.353]	[-6.462]	[-1.103]	[-3.140]
School quality†	1.802**	1.364	1.722**	1.272
	[2.512]	[1.591]	[2.105]	[1.424]
Average days absent†	0.879***	0.961	0.816***	0.902**
	[-4.537]	[-1.076]	[-7.401]	[-2.409]
n(User)	8,399		91,317	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Incident rate ratios are reported with t-statistics in brackets. Middle school type omitted in school type. Coefficients from separate models are from a bivariate regression of the dependent variable on a given covariate. Coefficients from joint models are from a multivariate regression of the dependent variable on all the above covariates. Total use refers to the sum of all news engagements (posts, clicks, likes, saves) and messages sent. SWD refers to students with disabilities; ELL refers to English language learning students; FRPL refers to students receiving free or reduced price lunch.

†Indicates the use of lagged values.

APPENDIX A

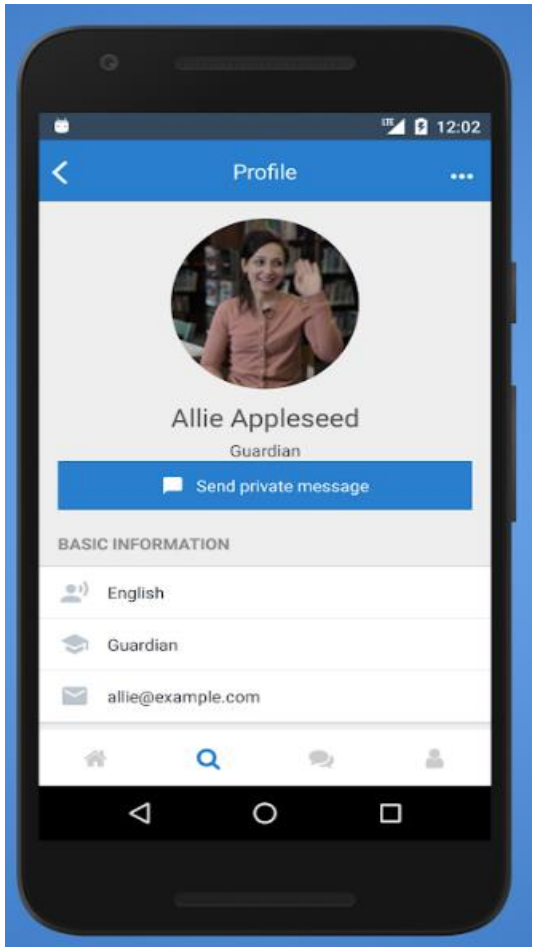


Figure A1: Example screenshot of a guardian user account from SchoolCNXT App

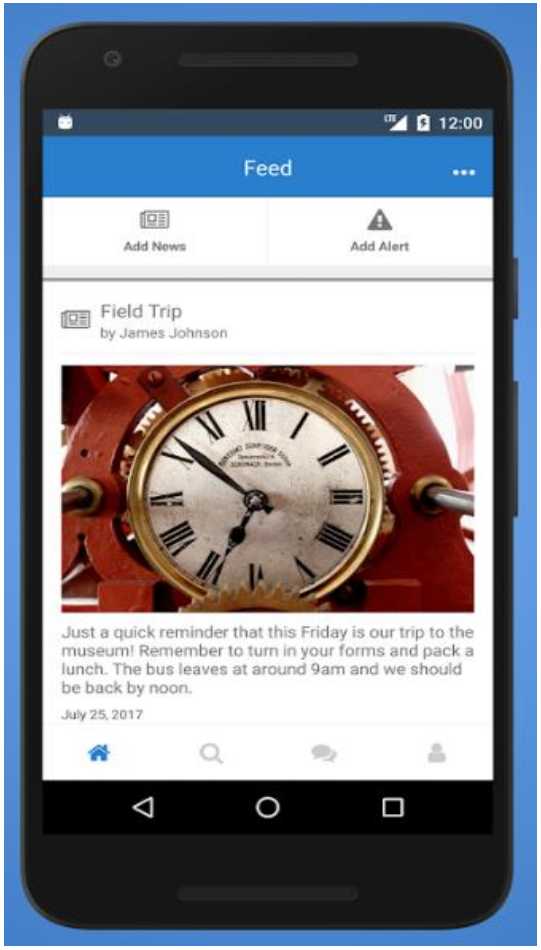


Figure A2: Example screenshot of a news post in a posting board from the SchoolCNXT App

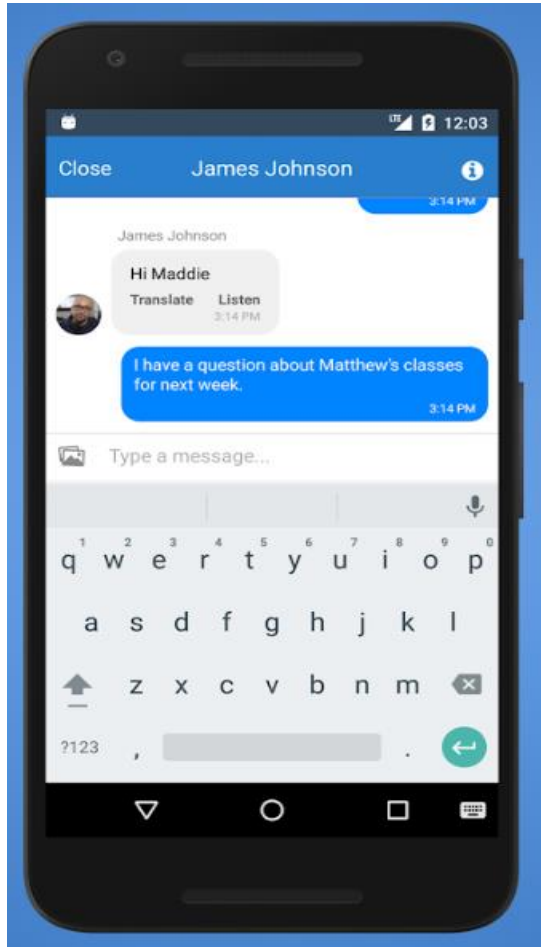


Figure A3: Example screenshot from messaging feature of the SchoolCNXT App

APPENDIX B

Table B1. Overall and Differential Attrition Analyses for Schools that Volunteered to Participate and Registered for SchoolCNXT

	Registered sample	Unregistered sample	p-value	Registered Sample		
				Treatment	Control	p-value
School characteristics						
Treatment (%)	0.51	0.40	0.51			
School type (%)						
Special needs	0.03	0.00	0.56	0.03	0.03	0.97
Early childhood	0.03	0.00	0.56	0.03	0.03	0.97
K–8	0.07	0.00	0.41	0.06	0.07	0.96
Elementary	0.47	0.50	0.84	0.47	0.47	0.99
Middle	0.10	0.10	0.99	0.10	0.10	0.95
High	0.30	0.40	0.53	0.31	0.30	0.94
Days absent	14.95	13.99	0.68	15.29	14.60	0.57
SWD (%)	22.33	21.32	0.82	22.08	22.58	0.85
ELL (%)	16.60	10.81	0.25	16.81	16.39	0.88
Male (%)	51.24	53.13	0.49	51.99	50.47	0.32
FRPL (%)	81.30	57.53	0.00	80.80	81.82	0.67
Race (%)						
African American	34.08	10.68	0.01	35.25	32.88	0.63
Asian	12.51	26.23	0.04	12.73	12.29	0.90
Hispanic	45.06	34.96	0.24	44.01	46.14	0.65
other	1.86	1.78	0.92	1.99	1.73	0.57
white	6.48	26.35	0.00	6.03	6.95	0.60
Teacher Characteristics						
Teacher annual salary	77,357	79,126	0.39	77,870	76,826	0.38
Female (%)	79.90	78.19	0.72	80.06	79.72	0.90
Race (%)						
African American	22.78	7.91	0.03	25.79	19.67	0.12
Asian	7.93	11.97	0.27	8.09	7.75	0.86
Hispanic	18.72	12.63	0.23	17.93	19.54	0.58
other	2.17	0.77	0.08	2.11	2.23	0.80
white	48.40	66.73	0.01	46.07	50.81	0.23
n(School)	122	10		62	60	

Notes. With the exception of School Types, Days Absent, Days Present, Total Credits Attempted, Total Credits Earned, and Teacher Annual Salary, all values are percents from 0-100. Teacher annual salary is reported in dollars. SWD refers to students with disabilities; ELL refers to English language learning students; FRPL refers to students receiving free or reduced price lunch.

APPENDIX C

Table C1. Overall and Differential Attrition Analyses for Schools that Returned the Administrator Survey

	Returned survey	Unreturned survey	p-value	Returned survey sample		
				Treatment	Control	p-value
School characteristics						
Treatment (%)	0.50	0.50	1.00	0.50	0.50	1.00
School type (%)						
Special needs	0.02	0.05	0.43	0.00	0.04	0.16
Early childhood	0.02	0.05	0.43	0.02	0.02	1.00
K–8	0.03	0.12	0.06	0.00	0.07	0.08
Elementary	0.50	0.40	0.31	0.51	0.49	0.84
Middle	0.12	0.05	0.18	0.13	0.11	0.75
High	0.30	0.33	0.70	0.33	0.27	0.50
Days absent	14.62	15.43	0.54	15.01	14.23	0.62
SWD (%)	21.31	24.27	0.25	19.67	22.96	0.16
ELL (%)	17.51	13.28	0.14	19.32	15.70	0.29
Male (%)	51.26	51.66	0.80	51.10	51.42	0.85
FRPL (%)	79.45	79.61	0.96	79.90	79.00	0.78
Race (%)						
African American	29.96	37.35	0.14	30.57	29.34	0.83
Asian	15.92	8.47	0.05	15.75	16.10	0.94
Hispanic	44.53	43.80	0.88	45.41	43.64	0.75
other	1.77	2.03	0.55	1.83	1.71	0.74
white	7.82	8.35	0.82	6.43	9.21	0.22
Teacher Characteristics						
Teacher annual salary	77,801	76,822	0.41	77,826	77,775	0.97
Female (%)	80.90	77.27	0.19	79.79	82.05	0.46
Race (%)						
African American	19.68	25.89	0.12	22.45	16.79	0.22
Asian	8.98	6.62	0.27	8.95	9.01	0.98
Hispanic	18.96	16.66	0.44	19.41	18.49	0.79
other	1.82	2.60	0.10	2.01	1.62	0.40
white	50.56	48.22	0.58	47.19	54.10	0.15
n(School)	90	42		45	45	

Notes. With the exception of School Types, Days Absent, Days Present, Total Credits Attempted, Total Credits Earned, and Teacher Annual Salary, all values are percents from 0-100. Teacher annual salary is reported in dollars. SWD refers to students with disabilities; ELL refers to English language learning students; FRPL refers to students receiving free or reduced price lunch.

APPENDIX D

NYC Parent Survey: The following items are from the 2016 and 2017 NYC School Survey for Parents. Respondents are instructed to "Please mark the extent to which you disagree or agree with each of the following statements about this school." Respondents then select from four-category Likert response ranging from *Strongly disagree* to *Strongly agree*. The four parent survey items we use are as follows:

- Staff at this school work hard to build trusting relationships with parents/guardians like me.
- My child's school communicates with me in a language and in a way that I can understand.
- School staff regularly communicate with parents/guardians about how parents can help students learn
- Teachers work closely with families to meet students' needs.

NYC Teacher Survey: The following items are from the 2016 and 2017 NYC School Survey for Teachers. Respondents are instructed to "Please mark the extent to which you disagree or agree with each of the following. At this school…" Respondents then select from a four-category Likert response ranging from *Strongly disagree* to *Strongly agree*. The four teacher survey items we use are as follows:

- There is an expectation that teachers communicate regularly with parents/guardians.
- Teachers work closely with families to meet students' needs.
- School staff regularly communicate with parents/guardians about how parents/guardians can help students learn.

APPENDIX E

Visual inspection of kernel density plots and multivariate imbalance statistics suggest that the comparison schools closely match the characteristics of the 132 participating schools on all measures used in the matching process. As a further test, we also examine the densities of other continuous covariates not used in the matching process including student-to-teacher ratio, percent of male students, and percent of students with disabilities at a school. Again, we find the distribution of these measures mirror each other closely across participating schools and comparison schools suggesting the matching process is successful at minimizing differences on a broader range of school characteristics beyond those used in the matching process. As a check for robustness, we run specifications that also match on and control for student achievement measures for math and ELA which are available for a subset of schools.

At the onset of this study, no other schools or individual teachers in NYC had begun to use the SchoolCNXT app as it was a relatively new platform. While we do not know the extent that comparison schools used other communication apps, responses to our baseline administrator surveys suggest these apps were not regularly used in a school-wide fashion and were likely used infrequently by individual NYC teachers. Only 6% of administrators in the experiment reported in the baseline survey using a mobile app as a primary means of school-wide communication with families and less than 5% considered apps a method regularly used by teachers.

Table E1. Measures of Statistical Imbalance Before and After CEM Algorithm across Experimental Schools and NYC Comparison Schools that did not Participate

	Preferred CEM		CEM Robustness Check	
	Pre-CEM	Post-CEM	Pre-CEM	Post-CEM
School type	0.116	0.000	0.142	0.000
ELL (%)	0.153	0.099	0.140	0.110
FRPL (%)	0.183	0.114	0.192	0.106
African American (%)	0.111	0.053	0.092	0.036
Hispanic (%)	0.109	0.109	0.114	0.052
Report Card PCA	0.138	0.131	0.135	0.098
Average Days Absent†	0.148	0.184	0.135	0.162
Student enrollment	0.160	0.133	0.119	0.156
Math achievement†			0.193	0.214
ELA achievement†			0.166	0.105
n(Comparison school)	1,669	642	1,460	366
n(Treatment school)	122	111		92
n(Strata)		379		564
n(Matched strata)		76		72

Notes. A score of 0 indicates perfect balance; 1 indicates perfect separation. Thus, a 0.01 change towards zero can be interpreted as a 1% improvement in balance across treatment and comparison schools. Coarsening occurs at median values for all variables except type, which has 6 bins corresponding to the different types of schools in the NYC School Quality Reports. ELL refers to English language learning students; FRPL refers to students receiving free or reduced price lunch.

†Indicates lagged value.

Table E2. School and Teacher Characteristics for Experimental and Matched Comparison Schools, 2016-17

	Full	Matched Schools	Experimental Schools	p-value
School level outcomes				
School quality score	-0.03	-0.03	-0.02	0.93
Math achievement	-0.1	-0.1	-0.13	0.67
ELA achievement	-0.09	-0.08	-0.12	0.60
Days absent	17.07	17.34	15.47	0.11
School level characteristics				
School type (%)				
Special needs	0.02	0.02	0.04	0.19
Early childhood	0.01	0.01	0.01	0.86
K–8	0.03	0.02	0.07	0.01
Elementary	0.5	0.5	0.48	0.66
Middle	0.1	0.1	0.09	0.75
High	0.34	0.35	0.32	0.51
SWD (%)	21.78	21.52	23.26	0.18
ELL (%)	18.02	17.9	18.67	0.64
Male (%)	51.7	51.81	51.09	0.42
FRPL (%)	80.82	80.64	81.86	0.41
Race (%)				
African American	31.45	31.32	32.25	0.73
Asian	11.27	10.96	13.07	0.24
Hispanic	47.78	48.04	46.3	0.51
other	1.95	1.93	2.07	0.58
white	7.55	7.76	6.31	0.26
Teacher level characteristics				
Teacher annual salary	80,841	80,924	80,386	0.38
Female (%)	77.58	77.32	79.01	0.29
Race (%)				
African American	21.64	21.5	22.44	0.66
Asian	6.23	5.87	8.21	0.24
Hispanic	19.74	19.91	18.79	0.49
other	3.23	3.17	3.55	0.23
white	49.17	49.56	47	0.27
n(School)	753	642	111	

Notes. We construct the school quality measure from a principal components analysis of the annual NYC DOE School Quality Reports from the previous year. Student achievement measures in math and ELA are based on New York State Assessments. We use scores from students' first time taking a test in a given year and standardize them in a given subject and grade to be mean-zero and have unit-variance before averaging standardized scores at the school level in each subject. With the exception of school quality score, achievement in math and ELA, days absent, school type, and teacher annual salary, all values are percents from 0-100. School type is reported in the portion of schools that are each type, respectively. Teacher annual salary is reported in dollars. Special needs schools refer to schools in the NYC district that specifically serve students with disabilities. SWD refers to students with disabilities; ELL refers to English language learning students; FRPL refers to students receiving free or reduced price lunch.

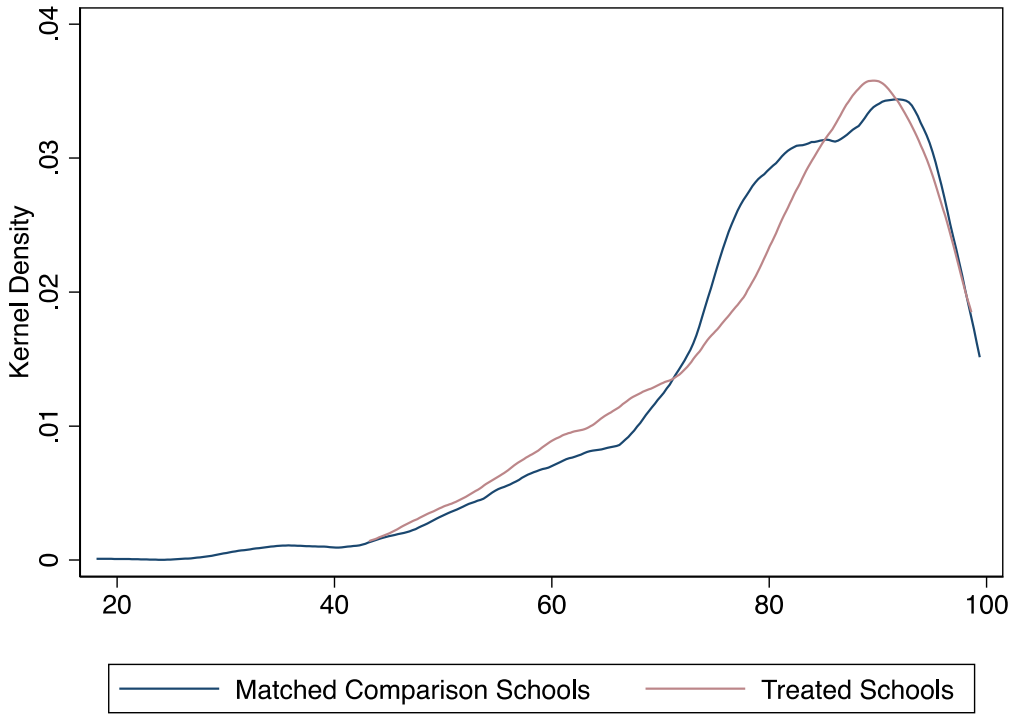


Figure E1: Kernel densities for the percent of students receiving free or reduced price lunch in participating study schools and NYC comparison schools

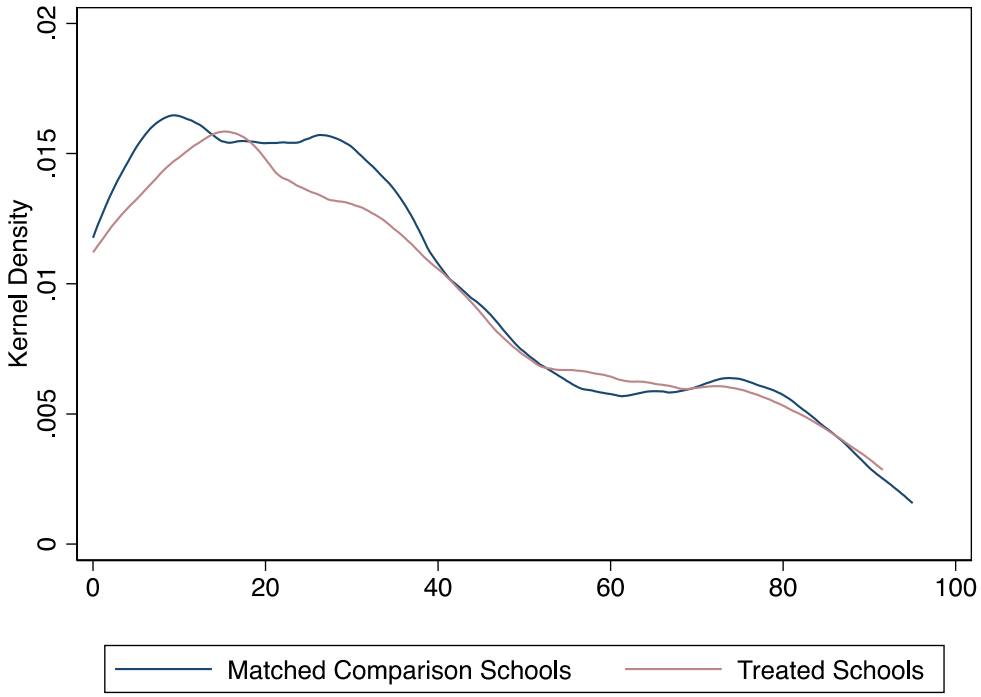


Figure E2: Kernel densities for the percent of African American students in participating study schools and NYC comparison schools

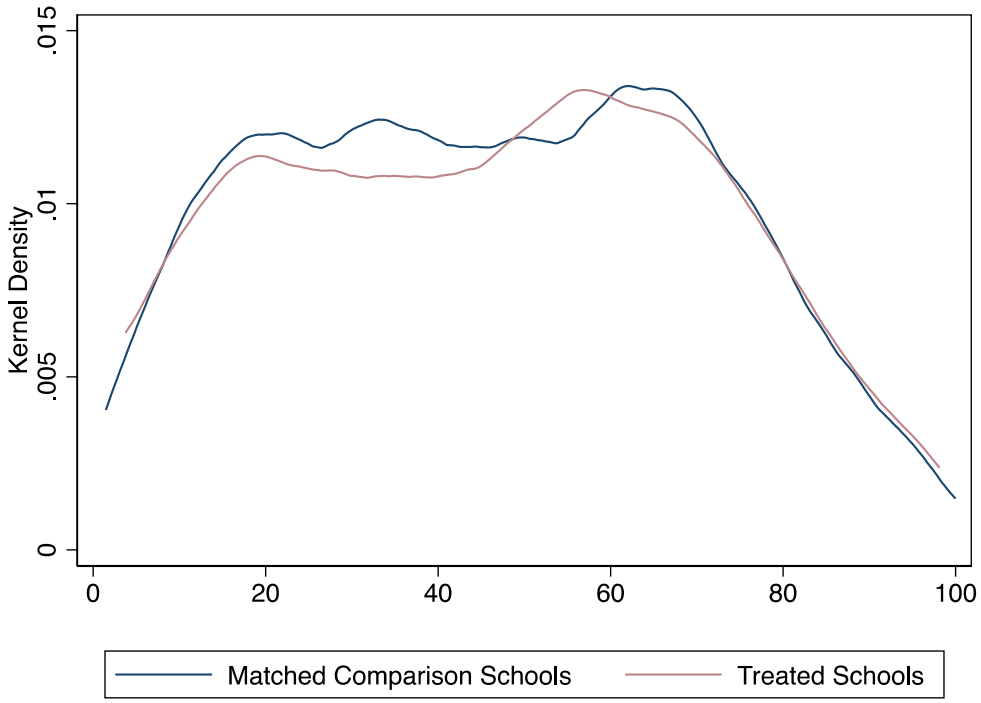


Figure E3: Kernel densities for the percent of Hispanic students in participating study schools and NYC comparison schools

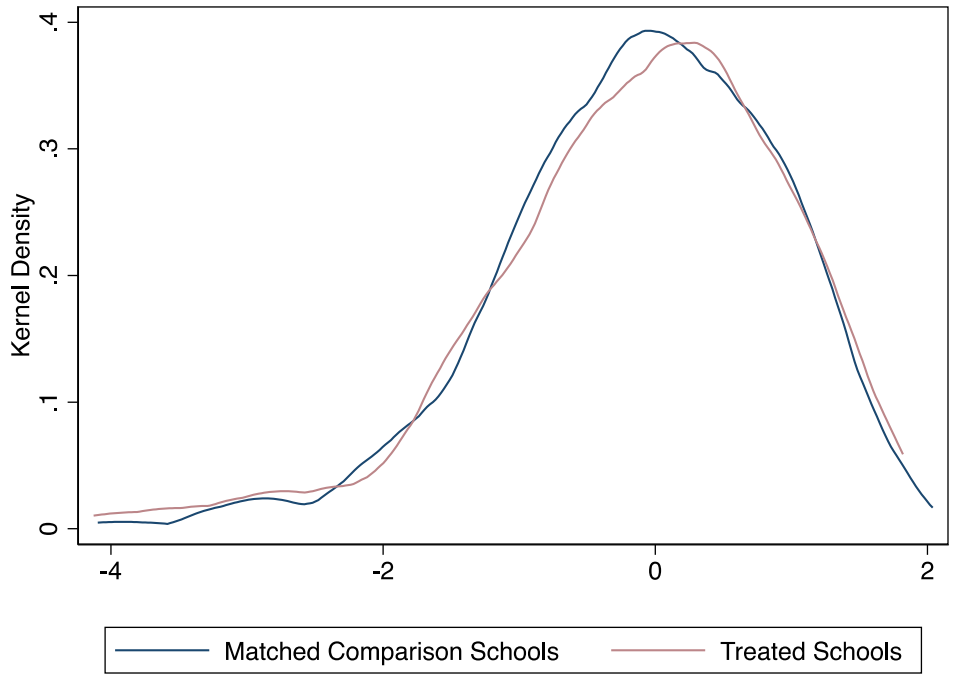


Figure E4: Kernel densities for a mean 0, unit variance measure of school quality based on NYC DOE school quality reports in participating study schools and NYC comparison schools

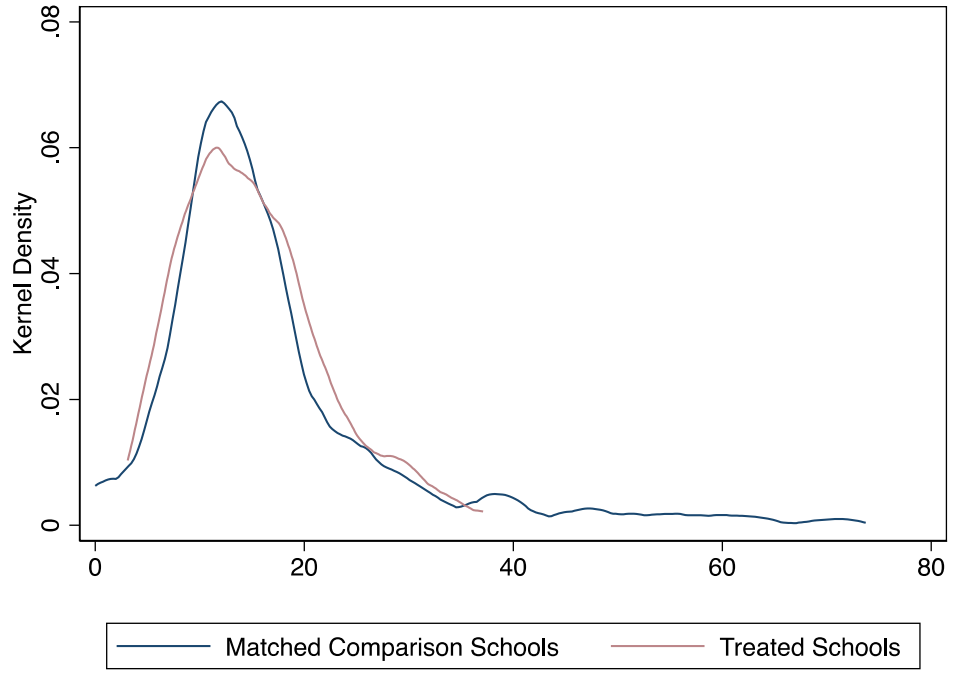


Figure E5: Kernel densities for the average number of absences per student in the previous year for participating study schools and NYC comparison schools

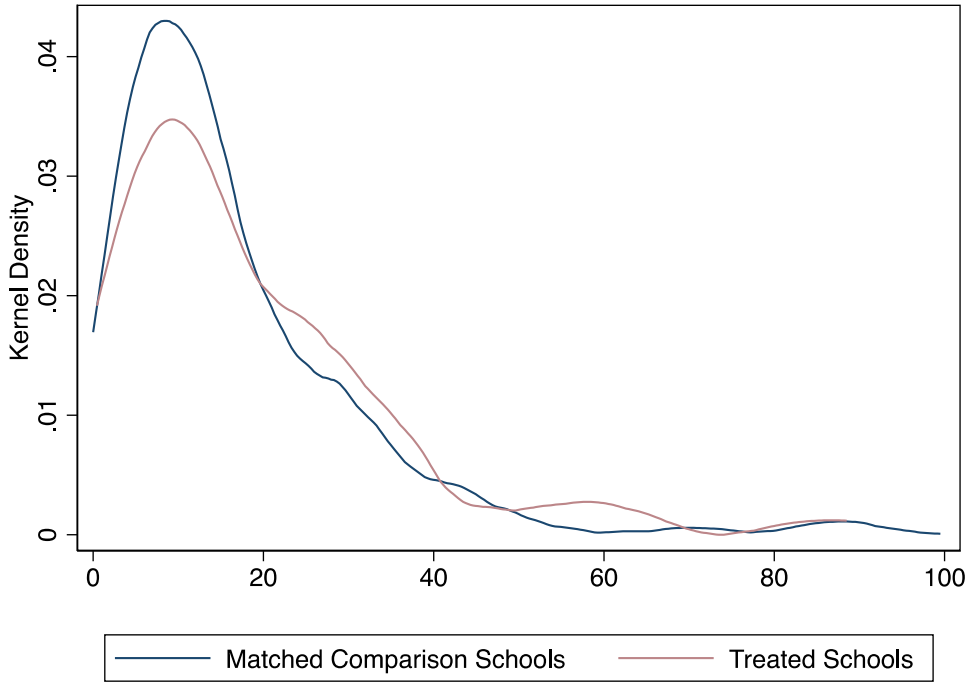


Figure E6: Kernel densities for the percentage of students designated as English language learners in participating study schools and NYC comparison schools

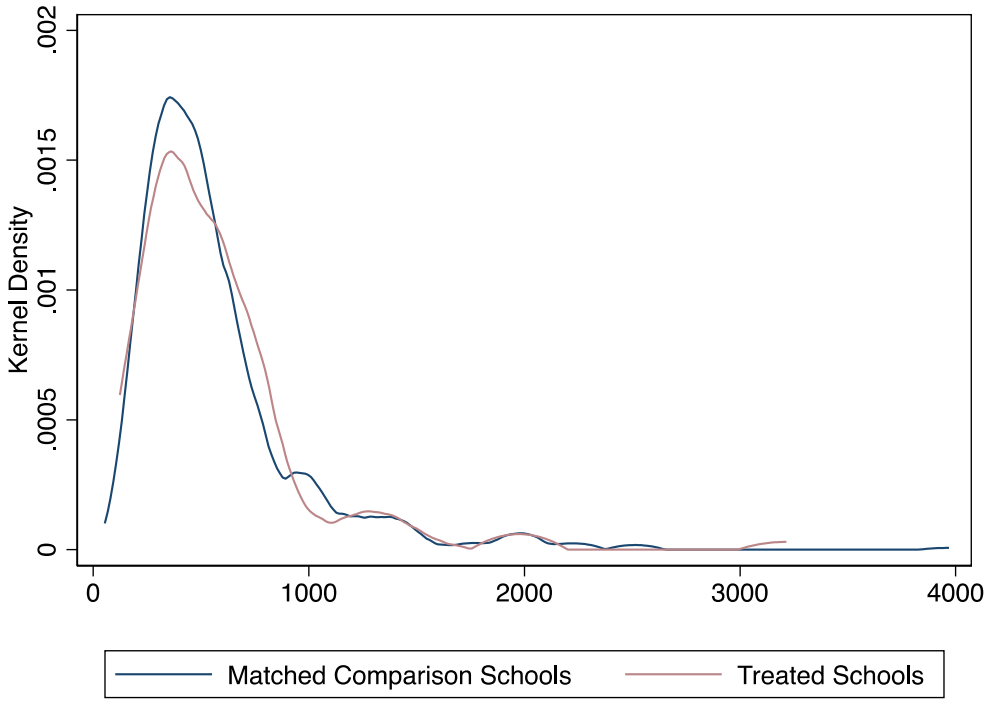


Figure E7: Kernel densities for student enrollments in participating study schools and NYC comparison schools

The following Appendix E figures refer to covariates not included in the CEM matching process

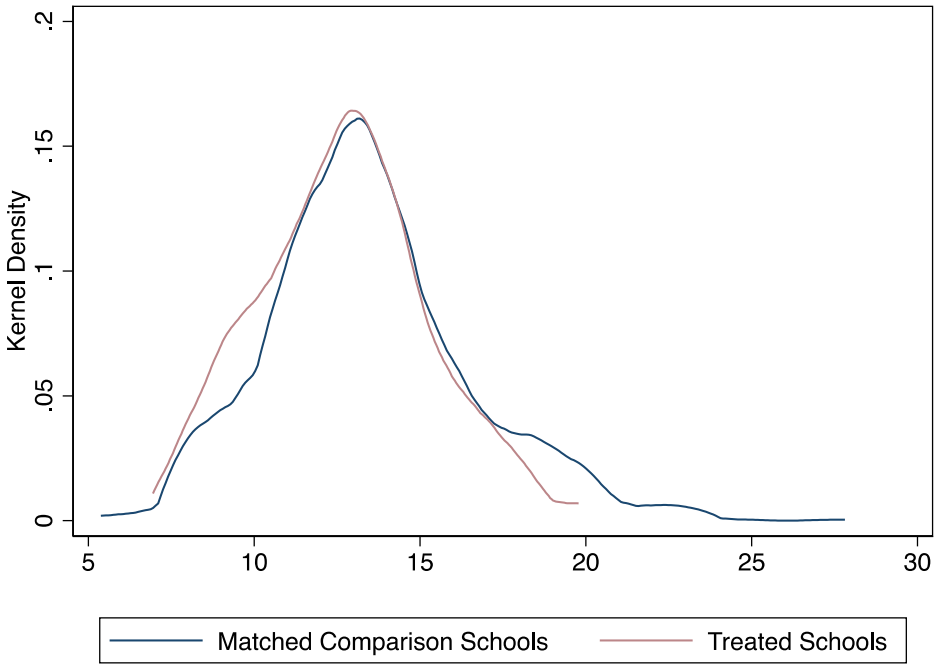


Figure E8: Kernel densities for student-to-teacher ratio in participating study schools and NYC comparison schools

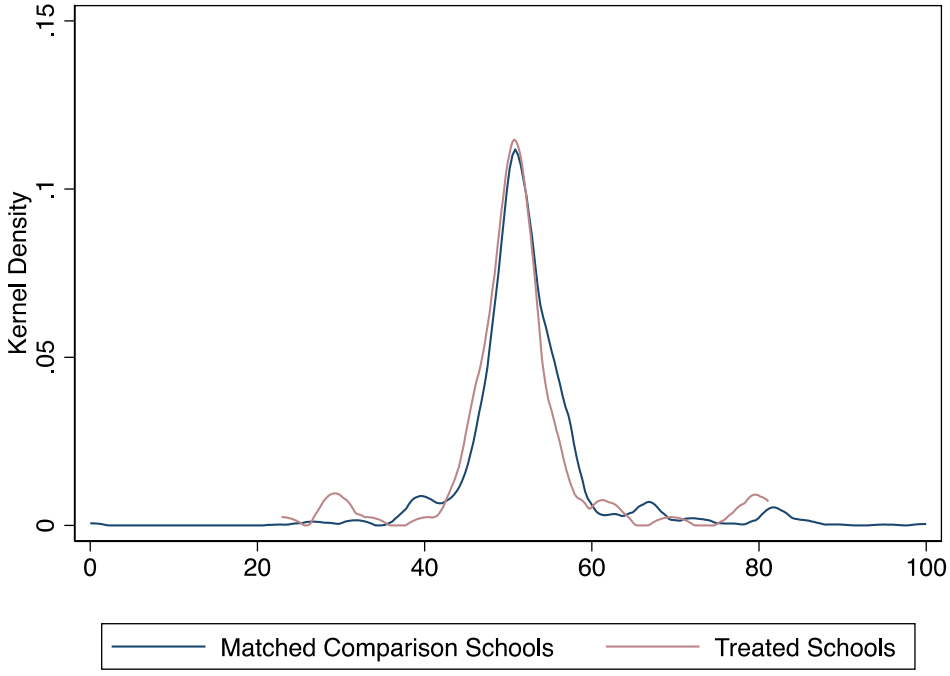


Figure E9: Kernel densities for percent of male students in participating study schools and NYC comparison schools

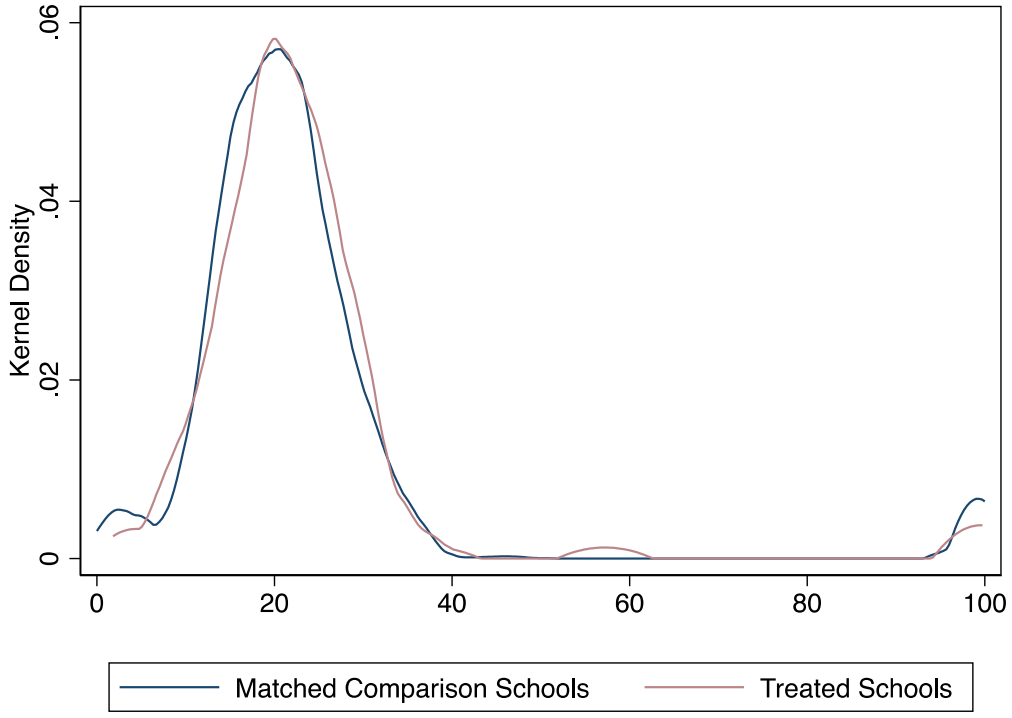


Figure E10: Kernel densities for percent of students with disabilities in participating study schools and NYC comparison schools

APPENDIX F

Table F1. The Effect of Intensive User Supports on App Activation and Usage with Imputed Zeros for Schools that Never Register, 2016-17

Model Type	Linear Probability Model		Negative Binomial					
Panel A: School Staff								
	Activation rate		Total use		Messages sent		News engagements	
Treatment	0.076	0.064*	1.764	1.989*	1.329	1.546	2.303	2.505**
	(0.047)	(0.039)	[1.230]	[1.687]	[0.680]	[1.112]	[1.496]	[2.098]
Control mean	0.44		2.47		1.37		1.11	
Control count total			11,578		6,399		5,179	
n(Staff) / n(School)			9,192 / 132					
Panel B: Parents								
	Activation rate		Total use		Messages sent		News engagements	
Treatment	0.028	0.019	2.361*	1.981*	1.020	0.954	2.962**	2.445**
	(0.024)	(0.020)	[1.788]	[1.693]	[0.046]	[-0.141]	[1.989]	[1.989]
Control mean	0.13		0.51		0.16		0.35	
Control count total			25,563		7,914		17,649	
n(Parent) / n(School)			100,483 / 132					
Controls	Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Linear probability model coefficients reported for activation rate; incident rate ratios reported for all other outcomes. Standard errors are clustered at the school level and reported in parentheses and t-statistics in brackets. These estimates are from a conservative approach where users from 10 schools that never registered are assigned values of 0 for activation and usage outcomes. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male.

APPENDIX G

Table G1. The Effect of Intensive User Supports on App Activation and Usage with Randomization Block Fixed Effects, 2016-17

Model Type	Linear Probability Model		Negative Binomial					
Panel A: School Staff								
	Activation rate		Total use		Messages sent		News engagements	
Treat	0.054**	0.043*	0.974	1.408	0.952	1.185	1.034	1.928
	(0.027)	(0.024)	[-0.042]	[0.433]	[-0.076]	[0.210]	[0.056]	[0.991]
Control mean	0.48		2.73		1.51		1.22	
Control total			11,578		6,399		5,179	
n(Staff) / n(School)			8,399 / 122					
Panel B: Parents								
	Activation rate		Total use		Messages sent		News engagements	
Treat	0.001	0.021	0.749	1.395	0.850	1.166	0.744	1.813
	(0.017)	(0.015)	[-0.490]	[0.487]	[-0.294]	[0.281]	[-0.489]	[0.947]
Control mean	0.15		0.57		0.18		0.39	
Control total			25,563		7,914		17,649	
n(Parent) / n(School)			91,317 / 122					
Block FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls		Yes		Yes		Yes		Yes

Notes. * p<0.10, ** p<0.05, *** p<0.01. These estimates are from a sample that does not assign zeros for activation and usage outcomes in schools that did not register; instead those schools receive a missing value for these estimates. Linear probability model coefficients reported for Activation rate. Incident rate ratios reported for all other outcomes. Standard errors are clustered at the school level and reported in parenthesis and t-statistics are in brackets. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male.

APPENDIX H

Table H1. The Effect of Intensive User Supports on Administrator, Teacher, and Parent Perceptions of Communication Quality Between Schools and Home using Randomization Block Fixed Effects, 2016-17

Model type	Ordered Logistic				Ordinary Least Squares			
	Administrator perceptions				Teacher perceptions		Parent perceptions	
	School-wide		Individual†					
Treatment	3.722*	4.527	1.170	0.483	-0.072	-0.091	-0.097	-0.085
	[1.769]	[1.480]	[0.244]	[-0.829]	(0.109)	(0.094)	(0.126)	(0.109)
n(School)	90				132			
n(Respondents)	90				4,970		34,598	
Block FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Administer perceptions of school-wide and individual teacher communication effectiveness are measured, respectively, by questions on the End of Year survey we administer. Teacher and parent perceptions are measured by a PCA on multiple questions from the NYC End of Year school survey for teachers and parents, respectively. Proportional odds ratios are reported for estimates of treatment effects on administrator perceptions. Standard errors are clustered at the school level and reported in parenthesis and t-statistics in brackets. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male. A lagged dependent variable is included as a control in specifications where teacher and parent perceptions are the outcome.

†Administrator perceptions on communication quality are measured using a 5-item Likert response, however, due to convergence issues and low observation counts, the lowest category (sample size of 4) and second lowest category (sample size of 14) are combined into one category.

APPENDIX I

Table I1. The Effect of Intensive User Supports on App Activation and Usage in the Follow-up Year, 2017-18

Model Type	Linear Probability Model		Negative Binomial					
	Panel A: School Staff							
	Activation rate		Total use		Messages sent		News engagements	
Treat	0.029	0.049	1.761	3.743**	1.424	2.361	2.106	2.512
	(0.076)	(0.046)	[0.858]	[2.272]	[0.542]	[1.412]	[1.032]	[1.628]
Control mean	0.39		2.41		1.22		1.19	
Control total			10,003		5,058		4,945	
n(Staff) / n(schools)			8,105 / 122					
	Panel B: Parents							
	Activation rate		Total use		Messages sent		News engagements	
Treat	0.020	0.014	2.539	2.810**	1.190	1.409	3.014*	2.861**
	(0.020)	(0.016)	[1.483]	[2.222]	[0.272]	[0.696]	[1.699]	[2.177]
Control mean	0.09		0.41		0.11		0.31	
Control total			24,727		6,437		18,290	
n(parents) / n(schools)			119,388 / 122					
Controls	Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. LPM coefficients reported for Activation rate; incident Rate Ratios reported for all other outcomes. Standard errors are clustered at the school level and reported in parenthesis and t-statistics in brackets. Control covariates include student enrollment, a lagged school quality measure, lagged average student absences and the percentage of students in a school that are English language learners, students with disabilities, African American, Hispanic, white, and male.

APPENDIX J

Table J1. The Effect of Intensive User Supports on Student Outcomes, 2016-17

Panel A: Achievement				
Model Type	Ordinary Least Squares			
	Math Achievement			
Treatment	-0.052	-0.063	0.007	0.019
	(0.114)	(0.111)	(0.055)	(0.039)
n(Student)	41,309		39,198	
	ELA Achievement			
Treatment	-0.102	-0.102	-0.043	-0.032
	(0.097)	(0.098)	(0.049)	(0.032)
n(Student)	36,632		35,697	
Panel B: Days Absent				
Model Type	Negative Binomial			
Treatment	1.057	1.050	1.016	1.008
	[0.602]	[0.493]	[0.166]	[0.155]
n(Student)	76,801		66,055	
Controls			Yes	Yes
Lagged outcome				Yes

Notes. * p<0.10, ** p<0.05, *** p<0.01. Estimates in Column 1 are unconditional estimates on the unrestricted sample. Student achievement measures in math and ELA are based on New York State Assessments in elementary and middle school and Comprehensive English, Integrated Algebra, Algebra, and Geometry Regents exams in high school. We use scores from students' first time taking a test in a given year and standardize them in a given subject and grade to be mean-zero and have unit-variance before averaging standardized scores at the school level in each subject. Standard errors are clustered at the school level and reported in parentheses. Incident rate ratios are reported for number of absences with t-statistics in brackets. Control covariates include a categorical race/ethnicity variable with white as the omitted category, lagged absences, gender, and status as an English language learner, FRPL eligible, and student with disabilities. Lagged performance in math and ELA is included where noted.

APPENDIX K

We measure student achievement in math and ELA using New York State Assessments in elementary and middle school and Comprehensive English, Integrated Algebra, Algebra, and Geometry Regents exams in high school. We take scores from students' first time taking a test in a given year and standardize them within subject and grade to be mean-zero and have unit-variance. We then take school level averages for each subject.

Table K1. The Joint and Disaggregated Effect of App Access and at least Basic User Supports on Student Outcomes, 2016-17

Model Type	Weighted Least Squares											
	Math				ELA				Days Absent			
	Pooled		Disaggregated		Pooled		Disaggregated		Pooled		Disaggregated	
App w/ at least basic supports												
	-0.026	-0.019			-0.025	0.012			-1.644*	0.060		
	(0.081)	(0.048)			(0.076)	(0.045)			(0.869)	(0.181)		
App w/ intensive supports			0.002	0.030			-0.050	0.006			-1.174	0.203
			(0.106)	(0.063)			(0.097)	(0.057)			(1.073)	(0.242)
App w/ basic supports			-0.056	-0.073			0.003	0.019			-2.157**	-0.096
			(0.106)	(0.064)			(0.101)	(0.062)			(1.093)	(0.233)
n(Experimental Schools)							111					
n(Total Schools)			703				720				753	
p-value of t-test for equivalence			0.670	0.219			0.677	0.871			0.448	0.336
Controls		Yes		Yes		Yes		Yes		Yes		Yes

Notes. * p<0.10, ** p<0.05, *** p<0.01. Treatment refers to the full sample of schools that participated in our study. Standard errors are clustered at the school level and in parentheses. Control covariates include school type, student enrollment, a lagged school quality measure, lagged absences, and the percentage of students in a school that are African American, Hispanic, English language learners, FRPL eligible, and students with disabilities. Schools are matched based on school type and medial cuts of lagged average absences, a lagged school quality measure, student enrollment, and the percentage of students that are Hispanic, African American, ELL designated, and FRPL eligible. The CEM algorithm matched 111 of 122 study schools to 642 NYC comparison schools that did not participate in the study.

APPENDIX L

Table L1. The Effect of Intensive User Supports on Teacher and Parent Perceptions of Communication Quality in Schools and Student Outcomes Controlling for Lagged Dependent Variables, 2016-17

Model Type	Weighted Least Squares									
	Teacher perceptions		Parent perceptions		Math achievement		ELA achievement		Days absent	
Treat	0.124	0.152*	-0.001	0.029	-0.039	0.002	-0.032	0.018	-2.036	0.138
	(0.124)	(0.092)	(0.114)	(0.073)	(0.097)	(0.039)	(0.092)	(0.041)	(1.292)	(0.241)
n(School)	458		453		455		457		458	
Controls	Yes		Yes		Yes		Yes		Yes	

Notes. * p<0.10, ** p<0.05, *** p<0.01. Standard errors are clustered at the school level and reported in parentheses. Control covariates include school type, student enrollment, a lagged school quality measure, lagged absences, and the percentage of students in a school that are African American, Hispanic, English language learners, FRPL eligible, and students with disabilities. Lagged dependent variables are included in models with controls. Schools are matched based on school type and medial cuts of student achievement measures in math and ELA, lagged average absences, a lagged school quality measure, student enrollment, and the percentage of students that are Hispanic, African American, ELL designated, and FRPL eligible. The CEM algorithm matched 92 of 122 study schools to 366 NYC comparison schools that did not participate in the study.