Effects of a Video-Based Teacher Observation Program on the De-privatization of Instruction: Evidence from a Randomized Experiment

David M. Quinn*
quinnd@usc.edu
University of Southern California

Thomas J. Kane
Miriam Greenberg
Daniel Thal

Center for Education Policy Research
Harvard Graduate School of Education

*Corresponding author.

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Abstract

Purpose: US schools have traditionally been characterized by teacher privacy and independence, yet theory and empirical work suggest that peer observation and support – or "de-privatized instruction" – can help improve pedagogical practice. In this study, we investigate whether the introduction of video technology into a school – through a video-based teacher evaluation system called Best Foot Forward (BFF) – led to instructional de-privatization, even in the absence of program components designed to encourage de-privatization.

Research Methods: Eighty-five schools were randomly assigned to BFF or a control condition. After one school year, teachers and administrators completed web-based surveys about their experiences.

Findings: We find that BFF caused administrators to facilitate more peer support among teachers, made teachers more likely to share lesson videos with colleagues, led teachers to have more of their lessons seen by other teachers, and redistributed which teachers were providing instructional support to colleagues (with relatively newer teachers taking on a larger role in providing peer support).

Implications: Results suggest that video technology may be an effective tool for efforts to improve instruction by increasing peer observation and support.

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US schools have traditionally been characterized by teacher privacy and independence (Hargreaves & Fullan, 2012; Kardos & Johnson, 2007; Lortie, 1975; OECD, 2013), yet higher levels of teacher peer support and collaboration have been linked to greater student achievement, innovative climate, and improved reform implementation and sustainability (Coburn, Mata, & Choi, 2013; Frank, Zhao, & Borman, 2004; Leana & Pil, 2006; Pil & Leana, 2009). Reformers have therefore argued for the "de-privatization of instruction," or for increasing teachers' engagement with peer observation, feedback, and support (Hargreaves & Fullan, 2012; Quinn & Kim, 2017; Supovitz, 2002; Vanblaere & Devos, 2016; Wahlstrom & Louis, 2008). However, school systems have struggled to achieve that goal.

Among other impediments, schools often face organizational barriers to instructional de-privatization. In-person peer observation is difficult, given that teachers are responsible for instructing their own students during the school day. The introduction of video technology can help schools overcome this challenge by enabling teachers to observe their colleagues' lessons at their convenience (Borko, Koellner, Jacobs, & Seago, 2011; Calandra & Rich, 2015). The availability of video could lead to instructional de-privatization through at least two channels: 1) teachers may independently take the initiative to share lesson videos with colleagues, or 2) administrators may seize the opportunity of more easily facilitating teacher peer support. Past research shows that administrators often arrange for peer observation and support (Hawley, Rosenholtz, Goodstein, & Hasselbring, 1984; Youngs & Kings, 2002), and the existence of lesson videos removes logistical barriers to organizing peer observation.

Much of the research on lesson video, however, has focused on how video can be used as a professional development tool. Little is known about whether using video for a required activity—such as classroom observations—can help facilitate the de-privatization of instruction.

In this study, we use data from a randomized controlled trial of Best Foot Forward (BFF), a video-based teacher evaluation system, to investigate the potential of video technology to facilitate instructional de-privatization. While BFF required that participating teachers record their lessons for the purpose of formal review by their administrators, the program did not include components designed to encourage instructional de-privatization. Even though the program did not require participants to share lesson videos with colleagues, we hypothesized that a program-induced increase in the share of teachers collecting video would lead to an expansion of the use of video for other purposes, such as de-privatizing instruction. Specifically, we hypothesized that the availability of video technology through BFF would cause principals to more frequently request that teachers consult with one another for professional support, contributing to an increase in peer observation and collaboration. Results indicate partial confirmation of our hypotheses.

Using self-report data (Gonyea, 2005) from teachers and administrators, we find that BFF increased the extent to which administrators connected teachers with one another for professional support. Treatment group teachers were more likely to show their colleagues a video of themselves teaching, and had an increased number of lessons observed by colleagues (either in person or through video), with a particularly strong effect for teachers who had used lesson video prior to participating in BFF (compared to the effect among teachers who had not used video in the past). BFF did not lead participating teachers to receive more peer support, but did redistribute who provided support, with newer teachers providing support otherwise provided by

more experienced teachers. As discussed below, one potential reason for this redistribution may be that viewing colleagues' lesson videos enables teachers to seek peer support from their colleagues who are the most skilled, as opposed to seeking support from their most experienced colleagues by default.

We begin this article by providing background on the theoretical and empirical basis underlying efforts to improve teaching practice by de-privatizing instruction, and discussing the role that administrators play in this process. We then describe the potential that video holds to facilitate instructional de-privatization and foster teacher learning, before describing our study setting and the Best Foot Forward system. Finally, we outline our analytic methods, present our results, and offer explanations for the findings.

Background

De-privatization of Instruction and the Situated Perspective on Learning

Lortie (1975) described the process of socialization into the teaching profession as one of "self-socialization," (p. 79) in which teachers develop their instructional skills mainly through solitary trial and error. This stands in contrast to other skilled professions, in which new entrants are initiated into some common body of professional knowledge and continually hone their practice over the course of their careers by comparing their performance to some common benchmark of expertise. The professional isolation experienced by teachers, Lortie argued, made the field of education poorly suited for the development of "commonly held, empirically derived, and rigorously grounded practices and principles of pedagogy" (p. 79). To the extent that teachers did support one another's professional learning, it was usually limited to the sharing of brief and idiosyncratic tricks of the trade. This isolation remains common among teachers in US schools today (Hargreaves & Fullan, 2012; Kardos & Johnson, 2007; OECD, 2013).

The "situated perspective" on teacher learning (Putnam & Borko, 2000; Borko, 2004) offers a theoretical framework for understanding how self-socialization in teaching can inhibit instructional improvement. Unlike traditional perspectives on learning that focus on the individual, the situated perspective emphasizes the "interactive systems that include individuals as participants, interacting with each other as well as materials and representational systems" (Putnam & Borko, 2000, p. 4). Central to this perspective are the assumptions that learning is social in nature and that "discourse communities" play an important role in learning. Such communities "provide the cognitive tools – ideas, theories, and concepts – that individuals appropriate as their own through their personal efforts to make sense of experiences" (Putnam & Borko, 2000, p. 5). The atomized nature of the teaching force described by Lortie (1975), with its limited peer observation and feedback, offers no process by which teachers are enculturated into a community's shared dispositions and ways of thinking.

Scholars have theorized that breaking the norms of privacy among educators – or "de-privatizing instruction" – will help improve teaching and ultimately student learning (Little, 1982; Wahlstrom & Louis, 2008). Supovitz (2002) operationalized instructional de-privatization as "the extent to which teachers observe each other and receive suggestions or other feedback from colleagues" (p. 1602; others, including Wahlstrom & Louis [2008], have operationalized it similarly). By observing colleagues teach, being observed teaching, exchanging feedback, and discussing practice, teachers develop common professional standards of excellence and are able to continually improve their instruction (Little, 1982; Wahlstrom & Louis, 2008).

Empirical evidence has begun to accumulate that de-privatizing instruction can lead to instructional improvement (Taylor & Tyler, 2012). Changes in teachers' pedagogical practices have been shown to be predicted by the extent to which teachers participate in collaborative

discussion, interact with more expert colleagues, and seek instructional advice from colleagues (Parise & Spillane, 2010; Sun, Wilhelm, Larsen, & Frank, 2014; Supovitz, Sirinides, & May, 2010). Perhaps most importantly, the amount of information-sharing and interaction around instruction that teachers engage in have been shown to predict student achievement (Leana & Pil, 2006; Pil & Leana, 2009).

The administrator's role in de-privatizing instruction. In the traditional US public school, in which teachers' instructional interactions are limited, administrators could play an important role in de-privatizing instruction (Smylie, 1988). Administrators can help make instruction public through organizational means such as establishing cooperative work structures, or by encouraging individual teachers to share resources and techniques, coach less expert peers, and observe other teachers' instruction (Hawley et al., 1984; Wahlstrom & Louis, 2008; Youngs & Kings, 2002). Because administrators generally do not lead their own classrooms and are expected to perform classroom observations as part of their supervisorial duties, they are well-positioned to identify teachers whose strengths match other teachers' weaknesses, enabling them to broker mentoring relationships and match teachers with one another for collaborative endeavors.

Barriers to De-privatization

In practice, many barriers to instructional de-privatization exist. To begin with, the norms of privacy and autonomy discussed above are deeply ingrained in the teaching force. Consequently, the culture in many schools resists collaboration, which can discourage teachers from seeking assistance (Kardos, Johnson, Peske, Kauffman, & Liu, 2001; Little, 1990). The norm against seeking assistance may be particularly strong among more experienced teachers, who can view it as a sign of weakness (Little, 1990). In part due to the norm of privacy, and in

part due to individuals' personalities, some teachers feel anxiety about opening their practice up to scrutiny, and balk at requests to have their instruction observed by colleagues (Puchner & Taylor, 2006; Sherin & Han, 2004).

In addition to cultural norms and individual preferences, organizational barriers often make de-privatization difficult. Teacher peer observation requires either the coordination of teachers' free periods or the hiring of a substitute teacher to cover the observer's classroom. The use of lesson video has become an increasingly popular means of overcoming this particular challenge because it allows teachers to examine their peers' practice without being physically present to observe a teacher's lesson in real time (Borko et al., 2011; Calandra & Rich, 2015).

The potential for video to facilitate instructional de-privatization. Lesson video is a potentially powerful tool for teacher learning because many of its uses are well-aligned with key principles of the situated perspective on teacher learning. The situated perspective stresses the value of identifying learning opportunities within everyday practice, of recognizing teachers' classrooms and schools as powerful contexts for teachers' learning (Putnam & Borko, 2000), and of using classroom artifacts as vehicles for teacher learning (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Putnam & Borko, 2000). Classroom videos are "ecologically valid" classroom artifacts (van Es, Tunney, Seago, & Goldsmith, 2015) – that is, they offer teachers the opportunity to engage with an authentic representation of actual teaching practice. Furthermore, video enables teachers to be removed from the immediacy of the classroom, thus facilitating reflection (Lampert & Ball, 1998, as cited by van Es et al., 2015). In studies of the use of lesson video for teacher PD, teachers have reported that the process of observing colleagues' lesson videos as part of an organized learning community helped them learn new instructional strategies and better understand students' thinking (Borko et al., 2008). Consistent with the theoretical importance of

authentic classroom artifacts to teachers' learning, teachers in one study reported that watching videos of themselves or of colleagues was more helpful than watching published videos (Zhang, Koehler, & Lundeberg, 2015), and that watching videos of colleagues' lessons was as helpful as watching videos of their own lessons (Sherin & Han, 2004; Zhang et al., 2015).

Professional development programs that incorporate classroom video rely on formal structures through which teachers engage with video. Such structures range from the *highly specified*, in which external PD providers prescribe the PD goals and procedures, to the *highly adaptive*, in which the PD goals grow from the local context, and in which general guidelines – rather than strict procedures – are followed during meetings (Borko et al., 2011). A commonality among specified and adaptive video-based PD programs is the use of some organizing structure, even if that structure consists simply of scheduling time for teachers to meet routinely to review lesson videos in a highly adaptive manner. Much less is known about whether simply introducing video technology to a school, without the express purpose of establishing a video club, can help de-privatize instruction.

In many school districts, teachers must have a formal classroom observation one to three times per year. We hypothesize that if teachers had the opportunity to submit lesson videos in lieu of in-person observations, there would be an increase in the share of teachers collecting video, which would lead to an expansion of the use of video for other purposes, such as de-privatizing instruction.

How, and for whom, video might affect de-privatization. As noted above, some teachers are resistant to de-privatizing instruction; other teachers are interested but are deterred by logistical constraints. For the latter group of teachers, making video technology available in schools - and incentivizing teachers to record themselves by allowing them to submit lesson

videos in lieu of required in-person classroom observations - may help de-privatize instruction. This could happen for two main reasons: first, teachers may, through their own initiative, seize the opportunity to share lesson videos with their colleagues. Teachers with certain dispositions or prior experiences – for example, those who have used video to record themselves teaching in the past – may be more likely to take advantage of an opportunity to de-privatize through video. Past use of lesson video may therefore indicate teachers' propensity for future use of video either because their prior experience with video made them more comfortable using video, or because past use of video is a signifier of their pre-existing willingness to use video. Second, administrators – in their role as support-brokers – might encourage teachers to share recorded lessons with colleagues. This may occur if the principal wants the teacher to share an example of effective instruction, if the principal wants the teacher to receive feedback on the video, or if the principal is encouraging a collaborative lesson study process. With the encouragement of an administrator, some teachers who may have otherwise not been inclined to share lesson videos may decide to do so.

Because the purpose of lesson observation is to initiate discussion about instruction, video technology may lead to an increase in the amount of instructional support that teachers provide one another. Depending on teachers' reasons for sharing video, teachers may experience an increase in the amount of peer support they receive or that they provide (or both). Additionally, the effect of video on teacher peer support may differ depending on teacher characteristics. If the teachers who share videos are teachers who had not previously been sources of instructional support to other teachers, their colleagues' new awareness of their instructional strengths may lead the videotaped teacher to receive an increased number of requests for support. At the same time, a teacher who is already an important source of support

for other teachers may not experience a similar increase in requests for support after sharing lesson videos.

Summary and Research Questions

Schools in the US have traditionally been characterized by teacher autonomy and isolation, where teachers seldom observe one another's teaching or exchange feedback for the purpose of improving instruction. The situated perspective on teacher learning, which proposes that learning occurs when teachers engage with their colleagues around instructional issues relevant to their context, helps explain how norms of privacy can inhibit instructional improvement. While various organizational and cultural barriers can prevent the de-privatization of instruction, video offers a solution to one important structural barrier by removing constraints of time and space. Video may also make it easier for administrators to orchestrate peer support among teachers. However, little is known about the extent to which introducing video technology into a school – without a formal structure for peer video-sharing – may facilitate instructional de-privatization. While lesson video is by no means the only way to support teachers' professional learning – for example, support can also be directly offered through various professional development initiatives (e.g., Borko, 2004) – making video technology available to teachers could be a simple, low-cost way to facilitate instructional de-privatization.

This study investigates whether introducing video technology into a school, through a video-based teacher evaluation system, can de-privatize teaching, and whether the effect of video on de-privatization differs depending on teacher characteristics. Specifically, this study uses data from a randomized control trial of Best Foot Forward (BFF), a video-based classroom observation system, to ask the following questions:

1) Does introducing a video-based teacher evaluation system cause administrators to orchestrate more peer support among teachers?
2) Does introducing a video-based teacher evaluation system make teachers more likely to have their teaching seen by other teachers?
    - Do effects differ by teacher background characteristics?
3) Does introducing a video-based teacher evaluation system cause teachers to give or receive more peer instructional support?
    - Do effects differ by teacher background characteristics?
4) Does principal orchestration of peer support explain any observed experimental effects on instructional de-privatization?

Methods

Design, Setting, and Participants

A school-level randomized experiment of BFF was conducted over the 2013-2014 school year involving 85 schools across 4 states and 16 school districts or charter organizations.[1] The project recruited schools by inviting principals to informational webinars and in-person meetings. After principals consented, teachers from their schools were recruited to participate. There were no qualifying characteristics required of principals or schools, but the following requirements were made of participating teachers: 1) they must have had at least one prior year of value-added data and classroom observation scores, 2) they must have been teaching a tested subject (e.g., math, reading), and 3) they must have been teaching students capable of completing written surveys (i.e., students in third grade or above and without severe disabilities). Participating schools were given a $1000 award; teachers were given a $750 stipend and were allowed to keep the video camera they were provided for recording their lessons (control group

teachers received a $250 stiped).

Participating schools were organized into 11 randomization strata based on their US state, school percent free or reduced-price lunch (FRL), and school proficiency rates on the state standardized math and reading tests. Within each stratum, roughly half of the schools were randomly selected for treatment; the remaining schools were assigned to the business-as-usual control group.

The Intervention: Best Foot Forward (BFF)

The larger purpose of the BFF intervention was to improve the teacher observation and evaluation process in a number of ways. BFF replaced the in-person classroom observations conducted by administrators as part of teachers' formal job evaluations with video-based lesson observations. During each of the three 1-2 month observation windows over the school year, BFF teachers recorded themselves teaching (as many times as they chose) and uploaded videos to a secure server (so as to protect the privacy of teachers and students). Teachers then selected one video per observation window from this bank to share with their administrator. Teachers completed a series of reflection questions and rated their video using their state or district rubric, as usual. Administrators viewed teachers' chosen videos online through the secure server and formally rated the lesson using the state or district rubric, as usual. Administrators had the option of tagging comments to specific moments in the video. After rating and annotating the video, the administrator shared the scores with the teacher prior to an in-person meeting. During this meeting, the teacher and administrator discussed the administrator's feedback on particular video clips.

Although BFF was designed to provide teachers with feedback to improve their instruction, the process might be considered summative in the sense that the submitted videos

were used for teachers' formal evaluations. For the purpose of these summative evaluations, teachers were encouraged to put their "best foot forward." This is relevant for our de-privatization outcomes, because with higher-quality lessons such as these, principals may be more likely to recommend teachers share their videos with their peers as positive exemplars, as opposed to recommending they share their videos with peers so as to receive support.

Prior to the intervention, principals attended a half-day training in which they learned how to use the online platform and were coached in providing video-based feedback to teachers. Teachers also attended a half-day training in which they learned how to use the equipment to record, upload, and access their ratings and feedback.

As noted, our interest in the present study is specifically in the impact of video-based observation on instructional de-privatization. In other work, we find that BFF led to improvements in various outcomes related to the teacher evaluation process (Kane, Gehlbach, Greenberg, Quinn, & Thal, 2015), but did not significantly impact student test scores (Kane, Blazar, Gehlbach, Greenberg, Quinn, & Thal, 2018. As we argue in the Discussion section of this article, the null effect on student learning should not be interpreted to mean that instructional de-privatization is unimportant.

Measures

All participating teachers and administrators were asked to complete a baseline survey in the fall of 2013 before treatment began, and a post-intervention survey in the spring of 2014. Overall response rates were high (teacher baseline=97%, teacher end-of-year=92%; administrator baseline=95%, administrator end-of-year=91%) and did not differ by condition.[2]

Outcomes. The outcomes in this study were survey items included on the teacher and administrator end-of-year surveys. To measure the extent to which administrators brokered peer

support among teachers, we asked administrators: “This past school year, how many times did you request that a teacher connect with another teacher at your school for professional support?” Answer choices were discrete count options ranging from 0 to “10 or more.”

Consistent with Supovitz (2002), we used two categories of questions to operationalize instructional de-privatization: 1) questions about the extent to which teachers observed each other, or “instructional exposure,” and 2) questions about the extent to which teachers exchanged feedback, or “instructional support.”

Instructional Exposure. To measure whether assignment to BFF made teachers more likely to share a video of their teaching with colleagues, we asked teachers in the spring, “Since January of this year, have you shared a video of your teaching in a professional learning community (PLC) or other collaborative group?” with options for “yes” or “no.” To understand the range of exposure, we asked teachers, “Since January of this year, how many other teachers have seen you teach (either on video or in person)?” (We call this variable “Num. Seen Teach”). To learn of the intensity of exposure, we asked, “Since January of this year, how many different lessons of yours have been seen by other teachers (either on video or in person)?” For the latter two questions, answer choices were discrete count options ranging from 0 to 5 with a censored option of “more than 5.”

Instructional Support. We used two items to measure instructional support. One item was based on teachers’ answers to the question, “This past school year, how many times did you receive professional support from a colleague?” To measure the amount of support provided by study teachers to other teachers, we asked, “This past school year, how many times did you give

professional support to a colleague?" For each question, answer choices included discrete count options of 0 to 5, and a final choice of "more than 5."

Analytic Plan

Right-censored Poisson regression. As described earlier, many of our outcomes are count variables with right-censoring; this makes them ill-suited for OLS regression. We therefore analyze these outcomes using right-censored Poisson regression (Raciborski, 2011). In conventional Poisson regression, the log of the conditional mean of the outcome is modeled as a linear function of the predictors. When the outcome is censored, a traditional Poisson regression model will yield (downwardly) biased and inconsistent parameter estimates (Raciborski, 2011). Right-censored Poisson regression accounts for censoring by treating the observed outcome variable y as a measure of the unobserved latent variable y^*. If y^* is censored at a value *c*, then for person *i*:

$$y_i = \begin{cases} y_i^*, & if\ y_i^* < c \\ c, & if\ y_i^* \geq c \end{cases}$$

For our censored count outcomes ("Admin Connection Request," "Num. Seen Teach," "Num. Lessons Observed," "Support Received," and "Support Given"), we fit right-censored Poisson regression models of the general form:

$$\ln\left(\mathrm{E}(\mathrm{y}_\mathrm{i}^*|\mathbf{x_i})\right) = \beta_0 + \beta_1 Treatment_i + \sum \beta_j x_i, \qquad (1)$$

where $\ln\left(\mathrm{E}(\mathrm{y}_\mathrm{i}^*|\mathbf{x_i})\right)$ is the natural log of the conditional expected value of the latent outcome for person *i*, $Treatment_i$ is an indicator for whether person *i*'s school was randomly assigned to treatment, and $\sum \beta_j x_i$ represents the sum of the effects of control variables included to improve the precision of our treatment effect estimates (as required by the study design, we also include dummy variables for randomization strata; see online Appendix A). In model 1, β_1 is the coefficient of interest, representing the causal effect of treatment assignment on the log of the

outcome conditional mean (controlling for the other predictors in the model). In this form, β_1 is difficult to interpret; exponentiating its value yields the incidence rate ratio (IRR), or the multiplicative factor by which the treatment affected the outcome (compared to the control group). For interpretive purposes, we convert coefficients to IRRs in text (but report coefficients in their original form in tables); we also include graphs demonstrating the predicted marginal effects (i.e. the treatment/control contrasts expressed by comparing predicted values for prototypical participants with mean values on the control variables).[3]

To test for the treatment interactions described above, we fit models of the general form:

$$\ln\left(\mathrm{E}(\mathrm{y}_\mathrm{i}^*|\mathbf{x_i})\right) = \beta_0 + \beta_1 Treatment_i + \beta_2 C_i + \beta_3 (C_i \times Treatment_i) + \sum \beta_j x_i, \qquad (2)$$

where C_i represents the control variable to be interacted with treatment (i.e., teacher experience or past video use) and other terms are as defined above. In model 2, β_1 represents the main effect of treatment for the subgroup of teachers with a 0 value on C and the sum of β_1 and β_3 represent the treatment effect for teachers with a value of 1 on C.[4]

Logistic regression. As described above, we have one binary outcome indicating whether the teacher shared a lesson video with colleagues in a PLC or other collaborative setting. To analyze this outcome, we use the following logistic regression model:

$$\ln\left(\frac{P(y_i=1)}{1-P(y_i=1)}\right) = \beta_0 + \beta_1 Treatment_i + \sum \beta_j x_i, \qquad (3)$$

where $\ln\left(\frac{P(y_i=1)}{1-P(y_i=1)}\right)$ is the natural log of the odds that a teacher has shared a lesson video (compared to not sharing a lesson video) and the other terms are as described above. Again, β_1 is the coefficient of interest, representing the causal effect of treatment assignment on the log odds that a teacher shared a lesson video with his or her colleagues. For interpretability, we also present the predicted proportion of teachers showing a lesson video by condition. Similarly to what we described above for model 1, we add to model 3 an interaction between treatment and

the indicator of whether teachers have used video to record their lessons in the past.

Mediation analyses. To test whether the effect of the intervention on de-privatization of instruction was mediated by administrators' brokering of teacher peer support, we add a variable giving the number of connection requests reported by each teacher's administrator to the right-censored Poisson regression models and the logistic regression model. If, with the addition of this control, the treatment effect is no longer significant but the mediator (administrators' connection requests) is, this suggests that the effect of treatment on the outcome may have been brought about by the mediator variable. Note that in order to draw this conclusion, it is necessary to assume that there are no other confounding mediators and that there are no interactions between the effects of treatment assignment and the mediator; if either of these assumptions is not true, mediation effect estimates will be biased (Judd & Kenny, 1981; Valeri & VanderWeele, 2013).[5]

In all models described above, we cluster standard errors at the school level.[6]

Results

Descriptive Statistics and Treatment-Control Balance

In Table 1, we present descriptive statistics by condition for the analytic sample on all school-level, administrator, and teacher variables. Overall, randomization was successful in producing groups that were comparable on observable baseline school characteristics. However, the treatment group was ten percentage points lower (n.s.) than the control group in percentage of schools that were elementary (as opposed to middle schools), and at baseline a somewhat higher proportion of treatment teachers reported that they had videotaped their own lessons in the

past (.43 compared to .31, *p*=0.07).

<Insert Table 1>

Descriptively, treatment administrators had higher means on the censored "Admin Connection Requests" outcome variable compared to control administrators, and a higher proportion of treatment administrators' responses were censored (10 or more instances of connecting teachers), with 38% of the treatment group choosing the highest option, compared to 22% of the control group. A significantly higher proportion of treatment teachers reported having shared a lesson video with colleagues in a collaborative setting (the "Shared Video" outcome; .19 in treatment versus .11 in control).

Did BFF cause administrators to orchestrate more peer support among teachers?

In Table 2, we present estimates from the right-censored Poisson regression model predicting the number of times administrators reported having connected a teacher to another teacher for instructional support. The significant *Treatment* coefficient of .29 corresponds to an incidence-rate ratio of 1.3, indicating that treatment assignment caused administrators to connect teachers 1.3 times as often as they would have, had they been assigned to the control group.

<Insert Table 2>

In the upper left panel of Figure 1, we present the predicted number of times that administrators in each condition connected teachers with one another for instructional support, holding all other variables in the model constant at their means. As seen, treatment administrators made a predicted 6.3 connections, compared to 4.8 connections for control administrators.

<Insert Figure 1>

Did BFF make teachers more likely to have their teaching seen by other teachers?

In Table 3, we present estimates from logistic regression models predicting whether a teacher reported having shared a lesson video with colleagues in a PLC or other collaborative setting. In column 1, the significant *Treatment* coefficient of .911 indicates that the odds of a treatment teacher sharing a lesson video were 2.49 times the odds of a control teacher sharing a lesson video. As seen in the upper right panel of Figure 2, this model predicts that 17% of treatment teachers share lesson videos with colleagues, while only 8% of control teachers do (holding all controls constant at their means).

As seen in column 2 of Table 3, the effect of treatment assignment on teachers' video-sharing was not significantly different for teachers who had or had not used video in the past (and post-hoc test shows the difference-in-difference in predicted probabilities is also not significant).

<Insert Table 3>

In Table 4, we present results from right-censored Poisson models predicting the number of other teachers who had seen a lesson from the focal teacher ("Num. Seen Teach"), and the number of different lessons of a focal teacher's that had been seen by another teacher ("Num. Lessons Observed"). Treatment assignment did not lead teachers to expand the circle of teachers with whom they shared their instruction (column 1), and the treatment effect on this outcome did not vary depending on whether the teacher had used video in the past (column 2).

<Insert Table 4>

As seen in column 3, assignment to treatment had a significant main effect on the number of lessons that teachers shared with a colleague, with the treatment coefficient of .259 corresponding to an IRR of 1.3. In column 4, we see that this effect was driven by the subgroup of teachers who had used video to record lessons in the past. The treatment effect for teachers

who had not used video in the past was small and not significant (as evidenced by the *Treatment* coefficient in column 4), but adding the significant coefficient on the *Treatment*Used Video in Past* interaction to the *Treatment* coefficient shows that treatment teachers who had used video in the past had 1.83 times as many of their lessons observed by colleagues as did control teachers with past lesson video experience.

The lower left panel of Figure 1 shows treatment-control contrasts in the predicted number of lessons seen by colleagues separately for teachers who had and had not used video in the past. Teachers with no lesson video experience had roughly the same number of lessons seen by colleagues regardless of their treatment assignment (approx. 1.5 lessons). However, among teachers with lesson video experience, treatment assignment led to a boost from a predicted 1.26 lessons seen to a predicted 2.3 lessons seen.

Did BFF cause teachers to give or receive more peer instructional support?

In Table 5, we present estimates from right-censored Poisson regression models predicting the number of times that focal teachers received and gave instructional support. Treatment assignment did not affect the overall amount of support that teachers received (column 1), and this effect did not differ by teacher experience level (column 2).

<Insert Table 5>

As seen in column 3, treatment assignment had no main effect on the amount of support that teachers gave to their colleagues (column 3). Column 3 shows that overall, teachers above the sample median for years of experience reported giving more instructional support than did teachers with less experience (1.24 times as many instances of support-giving). In column 4, we find a significant, negatively signed *Treatment*High Experience* interaction. In this model, the significant coefficient on *Treatment* of .27 indicates that treatment assignment increased the

amount of support that relatively less-experienced teachers gave to their colleagues by a factor of 1.31. Adding the *Treatment* coefficient to the *Treatment*High Experience* coefficient, however, also shows that treatment assignment may have decreased the amount of support that more-experienced teachers provided, by a factor of .83 (p=.08). Another way of looking at this result is to note that in business as usual, high experience teachers provide support to their peers at about 1.55 times the rate as do low experience teachers (as implied by the *High Experience* coefficient in column 4); however, treatment redistributed who provided support, such that experience level no longer predicted how much support teachers provided to others (as indicated by the sum of the *High Experience* and *Treatment*High Experience* coefficients in column 4). We return to this finding in the discussion section.

The lower right panel of Figure 1 shows the predicted treatment-control contrasts on "Support Given" by teacher experience levels. Among more experienced teachers, treatment assignment reduced the number of times teachers provided support in the spring, on average, from 5.46 times to 5.01 times (p=.08). However, among teachers with fewer years of experience, treatment assignment led to an increase in the number of times teachers provided instructional support, from an average of 4.26 times to an average of 5.06 times.

Does principal orchestration of peer support explain experimental effects on instructional de-privatization?

We have seen that treatment assignment caused administrators to broker more peer support among teachers. Treatment assignment also made teachers more likely to share a lesson video with colleagues, caused teachers to have more of their lessons observed by colleagues (primarily among teachers who had used video in the past), and caused less experienced teachers to provide more support to their colleagues while causing more experienced teachers to provide

less support. Was it the increase in administrators' support brokering that led to these teacher outcomes? In Table 6, we present results to analyses testing for this mediation. Again, note that in this table, the sample sizes (and therefore effect estimates) do not match those from tables 2-5. The reason is that teachers whose administrators did not fill out the *Connection Requests* survey question had to be dropped from the mediation analyses (additionally, in the logit models, 13 teachers from one randomization bloc were dropped due to perfect prediction of outcome).

In columns 1 and 2 of Table 6, we test whether administrators' brokering led teachers to share their lesson videos with colleagues. We know that treatment made teachers more likely to share videos (column 1); however, when both *Treatment* and *Admin Connection Requests* are in in the model together (column 2), neither significantly predicts teachers' video sharing. While this does not rule out mediation, the result does not support the mediation hypothesis (however, when randomization blocs are excluded from the model to allow for the inclusion of the teachers dropped due to perfect outcome prediction, *Admin Connection Requests* significantly predicts video-sharing, with a slightly larger coefficient and smaller standard error compared to column 2 [b=.115, se=.054]) and the main effect of treatment is not significant (with a smaller coefficient and standard error [b=.502, se=.451]), consistent with the mediation hypothesis).

<Insert Table 6>

We find some evidence that administrators' brokering mediated the treatment effect on the number of teachers' lessons observed by other teachers. As seen in columns 3 and 4 of Table 6, the significant main effect of treatment disappears when controlling for the (significant) effect of *Admin Connection Requests*.

In columns 5 and 6 of Table 6, we test for mediation on the "Support Given" outcome for low experience teachers (the subgroup for whom an effect was observed). When *Admin*

Connection Requests and *Treatment* are both included (column 6), neither is significant[7] (for high experience teachers, *Admin Connection Requests* did not predict "Support Given"). Table 6 thus presents evidence that is consistent with, but not strongly in support of, mediation.

Discussion

In this study, we found that Best Foot Forward, a video-based teacher evaluation system, contributed to instructional de-privatization. BFF caused school administrators to increase the frequency with which they connected teachers with one another for instructional support, made teachers more likely to share lesson videos with colleagues, caused teachers to have more of their lessons observed by colleagues (an effect driven by teachers who had experience recording their lessons prior to the experiment), and caused relatively less-experienced teachers to provide more instructional support to colleagues while seemingly causing more experienced teachers to provide less support (without changing the overall amount of support given across teachers). Additionally, some (albeit weak) evidence suggests that the increase in teacher peer observation and support may have been due, at least in part, to administrators' increased support brokering.

One potential explanation for why BFF increased the frequency with which administrators referred teachers to one another for instructional support may be that the lesson videos provided an artifact for administrators to suggest that teachers share with colleagues. Perhaps teachers acted on this brokering and shared their videos with colleagues, leading them to have more of their lessons observed by colleagues either in person or on video. However, some teachers were more likely to take advantage of this opportunity presented by the video availability. Teachers' past use of video seems to be a reasonably effective indicator that teachers will take advantage of the opportunity to use video to de-privatize their instruction if given the chance (again, this could be either because past video use directly influenced teachers'

interest in using video, or because past video use signifies propensity to use video).

Why is it that the treatment did not also increase the number of teachers who had seen the focal teacher's instruction? This is somewhat surprising, given that the marginal cost of sharing the video with one more person is zero, while the marginal cost of being physically observed by another teacher is rising in the number of teachers. That is, given scheduling challenges, it's difficult to arrange for one teacher to observe another teacher in person; it's even more difficult to schedule 2 or 3 colleagues to observe. The explanation for the null effect may simply be statistical power; among teachers who had used video in the past, treatment teachers reported having been observed by 1.26 times the number of colleagues as did control group teachers, but this difference was not statistically significant. Alternatively, there may be a limited number of colleagues with whom a teacher has reason to share his or her instruction, creating a ceiling for the treatment effect. For example, if teachers are sharing videos in order to model grade-level or department-specific teaching practices, we might not expect teachers to expand greatly the circle of colleagues with whom they share their instruction, even if it is easier to do so. Similarly, we speculate it may be the case that there are a limited number of colleagues with whom teachers feel comfortable sharing their instruction, or from whom they expect to receive useful feedback.

For relatively less experienced teachers, these lesson-sharing processes were associated with an increase in the amount of instructional support they provided to their colleagues. One potential explanation is that, in the absence of BFF, teachers' default when seeking instructional support is to approach their more experienced colleagues. Because BFF increases instructional exposure, other teachers begin to discover the instructional strengths of less experienced teachers, and approach these less experienced teachers for advice. Relatedly, watching lesson videos may have led administrators to realize the instructional strengths of their less experienced

teachers and to therefore request that these teachers share lesson videos or provide support to their colleagues. Speculatively, it may be that administrators are now selecting teachers to provide support based more on actual observed classroom performance than seniority. In follow-up analyses, we find suggestive evidence consistent with this explanation. Specifically, when we interact teachers' previous value-added scores with treatment, we find a descriptively stronger, but not significantly different (p=.24), effect of assignment to BFF on support-giving among teachers with higher value-added scores (compared to teachers with lower value-added scores). Another possible explanation for the positive treatment effect among low-experience teachers is that less-experienced teachers were more comfortable with the video technology and with the web-based platform, and were therefore more likely to use the technology as a means of supporting other teachers.

This raises the question of who is benefiting from this instructional de-privatization. If BFF teachers are sharing videos with their colleagues primarily for the benefit of their colleagues (as opposed to sharing videos primarily so as to receive feedback on their own instruction), it may very well be the other (non-BFF) teachers at these schools who learned the most as a result of the BFF-induced de-privatization. This might also explain why, despite the increase in de-privatization, no effects on student test scores were observed – that is, it may be that the students who benefited from this de-privatization were the students taught by the non-BFF teachers in the treatment schools. Under a different program, in which teachers collect video primarily for formative purposes, we might find more video-sharing for the purpose of receiving feedback.

Limitations and Future Research

One limitation to this study is the self-report nature of our outcomes; teachers and administrators may not accurately recall the answers to our survey questions. Given that we did

not communicate our hypotheses related to de-privatization to study participants (who were aware of our goal to improve the teacher evaluation process), we do not expect social desirability bias to affect treatment participants' responses on these items. As such, any bias introduced by this response error is expected to be equal across treatment and control due to randomization, resulting in unbiased effect estimates. However, the predicted outcome values may be biased within condition; these predicted means should therefore be interpreted with caution.

When interpreting these results, it should also be kept in mind that administrators volunteered their schools as study sites, and teachers at these schools then volunteered to participate in the study. Because study participants (both treatment and control) differ from non-participants in that they showed an interest in using video for formal lesson observation, participants may be more tech-savvy, more open to innovations, and more interested in breaking down privatization barriers compared to the general population of administrators and teachers. The results from this study therefore may not generalize to administrators and teachers who are not interested in video-based observation and evaluation. Future work should further explore the teacher characteristics (such as perception of collaboration or past experiences with collaboration) and principal characteristics (such as instructional leadership) that influence whether teachers take advantage of opportunities to de-privatize.

While de-privatizing instruction can be an important first step toward instructional improvement, de-privatization alone may not be sufficient. Contextual factors will influence the extent to which de-privatization in any particular school leads to fruitful teacher learning (Coburn & Russell, 2008). For example, teachers with access to more expert colleagues will likely receive higher quality advice, and teams in which teachers develop higher levels of trust will likely be more successful in pushing team members toward instructional improvement (Bryk

& Schneider, 2002). Along these same lines, reviewing lesson videos of oneself or one's peers does not automatically lead to learning or instructional improvement (van Es et al., 2015); what de-privatization can do is unleash the potential for teachers to help one another improve. While this makes de-privatization a worthy focus of investigation in its own right, it is important to recognize that de-privatization alone may not be sufficient for instructional improvement. As a result, the findings in this study will be most useful to school improvement efforts when used alongside evidence about the circumstances under which peer observation and support leads to meaningful teacher learning and instructional improvement. At the same time, it should be noted that research suggests that new teachers experience more job satisfaction and retention in schools with supportive and collaborative cultures (Kardos & Johnson, 2007; Johnson, 2004). De-privatization may therefore indirectly affect student learning through improved professional climate and decreased teacher turnover, even if teachers' collaborative exchanges to not directly lead to improved instruction.

In this study, we have no data on precisely how videos were used when teachers shared them with colleagues, or what learning or instructional changes resulted from the increased support brokering, instructional exposure, and equalized instructional support. Investigating these processes is a logical next step in the study of how teachers may naturally use video technology to improve instruction through de-privatization outside of a formal lesson video club. Future research should also examine what school policies may affect the quality of teachers' de-privatization experiences, including efforts to encourage reflection on the videos, and how video might be used in the context of adopting and diffusing specific school-wide instructional reforms. Finally, the software used in this study was not designed to facilitate cross-school video-sharing. Yet teacher may value the opportunity to exchange videos with teachers at other

schools – particularly teachers who have few or no colleagues teaching the same course at their school (e.g., chemistry teachers). Another possible extension, therefore, would be examining video-based structures that facilitate cross-school de-privatization.

Conclusion

In US schools, the atomized structure of classrooms and the isolation of teachers thwart the development of a common vision of high quality instruction and a collective culture of instructional improvement. Breaking down these barriers can be an important component of school reform and instructional improvement. Video technology offers a way to facilitate the de-privatization of instruction by making teacher peer observation more convenient and less costly, and by making it easier for administrators to broker peer support among teachers. The results from this study serve as a proof of concept that introducing video technology into a school, and incentivizing teachers to record themselves by allowing them to submit lesson videos in lieu of required in-person classroom observations, can in fact lower the cost of sharing and discussing instruction. These results suggest the potential of video as a tool in efforts to de-privatize and improve instruction.

Notes

[1] A second year of the study was also conducted over the 2014-2015 school year; in that year, we did not survey teachers on de-privatization outcomes and therefore data from 2014-2015 are not included in the present article. A new set of participants was also added over 2014-2015; these participants, along with the 2013-2014 sample, represent the "pooled year 1" sample in Kane et al. (2018). Baseline data and response rates reported here differ from those reported in Kane et al. (2018) due to these sample differences.

[2] Based on our own review, for all but one outcome, analytic samples met the What Works Clearinghouse standards for "tolerable threat of bias [from attrition] under both optimistic and cautious assumptions." For the "Shared Video" outcome, attrition met the WWC's standards for "tolerable threat of bias under optimistic assumptions". Per WWC guidelines, we adjusted for variables that showed large differences at baseline.

[3] While the IRR makes the treatment main effect more interpretable, we do not report coefficients as IRRs in our tables because when expressed in this way, interaction coefficients can no longer be simply added to main effects coefficients to retrieve subgroup effects.

[4] We fit these models using the *rcpoisson* command (Raciborski, 2011) in Stata 14.

[5] The sample sizes in the mediation analyses are slightly smaller than the main impact analyses because teachers whose administrators did not complete the end-of-year survey could not be included in the mediation models. Some teachers were listed as having been observed by more than one administrator (e.g. a principal and a vice principal). In these cases, we took the mean number of connections reported by each administrator and truncated that mean to an integer, for consistency with the right-censored Poisson models.

[6] For the binary outcomes, multi-level logit models replicate the results presented here using

standard errors clustered at the school level (Multilevel right-censored Poisson models are not available in Stata).

[7] In the "low experience" subgroup model, we lose 13 teachers due to administrator non-response on the mediator; this explains why *Treatment* is not significant in column 1, in contrast to the result in Table 5.

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Table 1.

Descriptive Statistics by Condition for School-level, Administrator, and Teacher Variables (Predictors and Outcomes, Analytic Sample Only)

	Control			Treatment			
	Mean	sd	n	Mean	sd	n	*p*
School-level Variables							
Elementary	0.64		44	0.54		41	0.36
Percent FRL	54.98	33.36	44	57.33	27.73	41	0.28
Percent Minority	66.24	31.01	44	63.35	30.1	41	0.54
Percent Proficient ELA	70.63	21.83	44	72.21	18.84	41	0.88
Percent Proficient Math	66.51	20.12	44	66.17	18.01	41	0.58
Administrator Variables							
Years Experience	9.49	6.71	45	9.48	6.07	48	0.86
Admin Connection Requests (0 to ≥10)	5	3.32	45	6	3.58	48	0.15
Proportion Censored Admin Connection Requests	0.22		45	0.38		48	0.09
Teacher Variables							
Years Experience	12.02	6.59	147	11.8	6.79	148	0.87
Used Video in Past	0.31		147	0.43		148	0.07
Num. Seen Teach (0 to ≥6)	1.84	1.73	146	1.97	1.85	146	0.68
Proportion Censored Num. Seen Teach	0.06		146	0.1		146	0.23
Num. Lessons Observed (0 to ≥6)	1.78	1.88	147	2.16	1.95	147	0.11
Proportion Censored Num. Lessons Observed	0.11		147	0.12		147	0.75
Support Given (number of teachers; 0 to ≥6)	4.69	1.94	146	4.86	1.77	148	0.43
Proportion Censored Support Given	0.63		146	0.66		148	0.63
Support Received (number of teachers; 0 to ≥6)	4.08	2.11	147	3.97	2.07	148	0.61
Proportion Censored Support Received	0.48		147	0.44		148	0.40
Shared Video (in Collaborative Setting)	0.11		147	0.19		148	0.04

Note. P-value is for test of null hypothesis that treatment-control difference is 0, from linear OLS regression model controlling for randomization bloc (standard errors are clustered at the school level). Admin Connection Requests=administrator frequency of requesting that teachers connect with other teachers for instructional support. Num. Seen Teach=Number of other teachers who have seen the respondent teach this calendar year (in person or on video). Num. Lessons Observed=Number of respondent's lessons that were observed by other teachers (in-person or on video). Support Received=Number of times teacher reported receiving professional support from a colleague this calendar year. Support Given=Number of times teacher reported giving professional support to a colleague this calendar year. This table includes only data from participants over the 2013-2014 school year (year 1 of the study) because this was the only year in which de-privatization items were included on the survey. A new set of participants was also added over 2014-2015; these participants, along with the 2013-2014 sample, represent the "pooled year 1" sample in Kane et al. (2018). Baseline data and response rates reported in this table differ from those reported in Kane et al. (under review) due to these sample differences.

Table 2.

Right-Censored Poisson Regression Model Predicting Number of Times Administrator Requested that a Teacher Connect with Another Teacher

	(1) Admin Connection Requests b/se
Treatment	0.286*
	(0.143)
N	93

Note. Standard errors clustered at the district level in parentheses. All models control for fixed effects of randomization blocs, whether school is elementary vs. middle school, school % free or reduced-price lunch, school % minority, school % proficient at ELA, school % proficient at math, and an indicator for whether the respondent is above the sample median for years of experience. Admin connection requests=number of times the administrator reported connecting a teacher to another teacher for instructional support.

Table 3.

Logistic Regression Models Predicting Whether Teacher Shared Lesson Video in PLC or other Collaborative Setting

	(1) Shared Video b/se	(2) Shared Video b/se
Treatment	0.911*	0.876~
	(0.452)	(0.502)
Used Video in Past	0.153	0.096
	(0.390)	(0.516)
Treatment*Used Video in Past		0.091
		(0.807)
N	293	293

Note. Standard errors clustered at the school level in parentheses. All models control for fixed effects of randomization blocs, whether school is elementary vs. middle school, school % free or reduced-price lunch, school % minority, school % proficient at ELA, school % proficient at math, and an indicator for whether the respondent is above the sample median for years of experience.

Table 4.

Right-Censored Poisson Regression Models Predicting De-privatization of Instruction Outcomes

	(1) Num. Seen Teach b/se	(2) Num. Seen Teach b/se	(3) Num. Lessons Observed b/se	(4) Num. Lessons Observed b/se
Treatment	0.087	-0.013	0.259*	0.043
	(0.137)	(0.173)	(0.129)	(0.168)
Used Video in Past	0.257~	0.126	0.148	-0.178
	(0.138)	(0.206)	(0.131)	(0.193)
Treatment*Used Video in Past		0.242		0.561*
		(0.260)		(0.264)
N	292	292	294	294

Note. Standard errors clustered at the school level in parentheses. All models control for fixed effects of randomization blocs, whether school is elementary vs. middle school, school % free or reduced-price lunch, school % minority, school % proficient at ELA, school % proficient at math, an indicator for whether the teacher used lesson video in the past, and an indicator for whether the respondent is above the sample median for years of experience. Num. Seen Teach=Number of other teachers who have seen the respondent teach this calendar year (in person or on video). Num. Lessons Observed=Number of respondent's lessons that were observed by other teachers (in-person or on video)

Table 5.

Right-Censored Poisson Regression Models Predicting Instructional Support Outcomes

	(1) Support Received b/se	(2) Support Received b/se	(3) Support Given b/se	(4) Support Given b/se
Treatment	-0.020	0.075	0.041	0.270*
	(0.087)	(0.120)	(0.091)	(0.130)
High Experience	0.046	0.138	0.214**	0.441***
	(0.089)	(0.136)	(0.082)	(0.105)
Treatment*High Experience		-0.186		-0.459**
		(0.183)		(0.155)
N	303	303	302	302

Note. Standard errors clustered at the school level in parentheses. All models control for fixed effects of randomization blocs, whether school is elementary vs. middle school, school % free or reduced-price lunch, school % minority, school % proficient at ELA, and school % proficient at math. Support Received=Number of times teacher reported receiving professional support from a colleague this calendar year. Support Given=Number of times teacher reported giving professional support to a colleague this calendar year.

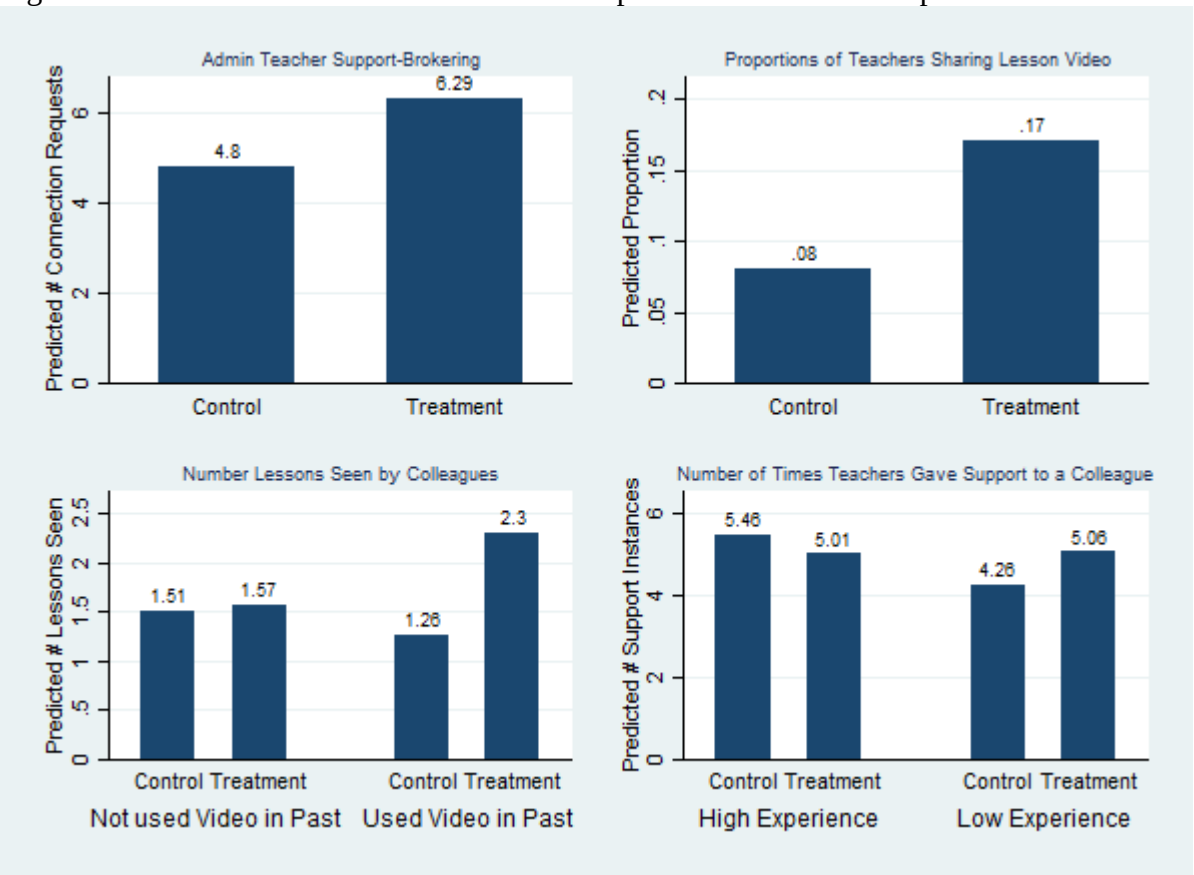
Table 6.

Models Testing "Admin Connection Requests" as Mediator of Treatment Effects on De-privatization Outcomes.

	(1) Shared Video (logistic regression)	(2) Shared Video (logistic regression)	(3) Num. Lessons Observed (Rt-censored Poisson)	(4) Num. Lessons Observed (Rt-censored Poisson)	(5) Support Given, Low Experience (Rt-censored Poisson)	(6) Support Given, Low Experience (Rt-censored Poisson)
	b/se	b/se	b/se	b/se	b/se	b/se
Treatment	0.946*	0.741	0.189*	0.109	0.115	0.032
	(0.455)	(0.502)	(0.088)	(0.080)	(0.123)	(0.136)
Admin Connection Requests		0.105		0.047***		0.035~
		(0.070)		(0.012)		(0.020)
N	262	262	274	274	139	139

Note. Standard errors clustered at the school level in parentheses. All models control for fixed effects of randomization blocs, whether school is elementary vs. middle school, school % free or reduced-price lunch, school % minority, school % proficient at ELA, school % proficient at math; columns 1 and 2 control for whether the teacher reported at baseline having used lesson video in the past; columns 1-4 include an indicator for whether the respondent is above the sample median for years of experience. Admin Connection Requests=administrator frequency of requesting that teachers connect with other teachers for instructional support.

Figure 1. Treatment-control contrasts on model-predicted values for de-privatization outcomes.



Note. All model-predicted values hold control variables constant at their sample means. Top two panels represent statistically significant treatment-control contrasts; bottom two panels represent statistically significant interactions. The treatment-control contrast for "Used Video in Past" in bottom left panel is statistically significant, as is the contrast for "Low Experience" in bottom right panel (contrast for "High Experience" is marginally significant).

Online Appendix A. Control Variables.

The use of a randomized design justifies causal inference in this study, but we included control variables in our models in order to improve statistical power and adjust for any chance imbalances across treatment and control (Altman, 1985). In all models, we included the following school-level control variables: a binary indicator for whether the school was an elementary school (vs. middle school), percent of the student body eligible for free or reduced-price lunch, percent of the student body that scored proficient on the previous year's state ELA test, percent of the student body that scored proficient on the previous year's state math test[1], and percent of student body that was non-white (additional potentially relevant control variables were not available). As required by the study design, we also included in all models a vector of dummy variables representing the randomization strata.

In the administrator model, we control for administrator experience through a binary variable indicating whether the respondent was above the sample median for years as an administrator (8 years). In the teacher models, we include a similar variable for years of experience teaching (sample median=11 years), which we interact with treatment in some models. For the instructional exposure models ("Shared Video," "Num. Seen Teach," and "Num. Lessons Observed"), we also include a binary indicator for whether the teacher reported at baseline ever having used video to record his or her own lesson ("Since you began teaching [not including pre-service training], have you ever used a video camera to record your own lessons?). Again, we interact this variable with treatment in some models.

[1] For one school, student proficiency rates were not available at the time of analysis; we therefore imputed the district mean proficiency levels for this school and included a missing data indicator in our models. Results are not sensitive to whether we impute or drop observations with missing school-level data.

References

Altman, D.G. (1985). Comparability of randomized groups. *Journal of the Royal Statistical Society. Series D (The Statistician), 34,* 125-136.