
Social Capital and the Diffusion of Innovations Within Organizations: The Case of Computer Technology in Schools

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Although the educational community has learned much about better educational practices, less is known about processes for implementing new practices. The standard model of diffusion suggests that people change perceptions about the value of an innovation through communication, and these perceptions then drive implementation. But implementation can be affected by more instrumental forces. In particular, members of a school share the common fate of the organization and affiliate with the common social system of the organization. Thus, they are more able to gain access to each others' expertise informally and are more likely to respond to social pressure to implement an innovation, regardless of their own perceptions of the value of the innovation. This article characterizes informal access to expertise and responses to social pressure as manifestations of social capital. Using longitudinal and network data in a study of the implementation of computer technology in six schools, the authors found that the effects of perceived social pressure and access to expertise through help and talk were at least as important as the effects of traditional constructs. By implication, change agents should attend to local social capital processes that are related to the implementation of educational innovations or reforms.

Although educators and educational researchers are learning about better educational practices, little is known about how to implement those practices (Bryk and Schneider 2002). Lost in the focus on producing new curricula and training teachers is the fact that schools are fundamentally social organizations. As such, schools implement reform and innovations

through localized social processes (D. K. Cohen 1995; Cuban 1990; Fullan 1991). This article discusses how social processes within schools affect the implementation of innovations, particularly the implementation of computer technology.

Educational researchers have identified an array of factors that may affect educational outcomes, ranging from constructivist teach-

ing (D. K. Cohen, McLaughlin, and Talbert 1993; Lave and Wenger 1991; Prawat 1989) to directed teaching (Delpit 1988; Slavin and Madden 2001), from the inequities of tracking (Alexander and Pallas 1985; Oakes 1985; Riehl et al. 1992) to the market potential of schools of choice (Chubb and Moe 1990; Friedman and Friedman 1980; Greene 2001). For each new understanding, there is a corresponding new reform or policy: Teachers should be retrained, schools should be reorganized, and students should be able to choose which schools they attend.

As complex social organizations, schools typically draw on informal processes to implement innovations or reforms. Thus, implementation of these reforms potentially places competing demands on the social structure of the school. But little is known about the relative importance of the social structure or the specific mechanisms through which social structure affects implementation.

To quantify and understand how social structure within schools affects diffusion, we applied the theory of social capital, operationalized as the potential to access resources through social relations. Thus, the basic research question that we address in this article is this: To what extent does a teacher's implementation of an innovation depend on the teacher's access and response to social capital?

If teachers draw on social capital to implement innovations, then reformers and innovators must consider the distribution of social capital in any school in which they seek to implement change. Is there enough social capital to implement the innovation? How does the distribution of social capital in a given school differ from exemplar or pilot schools? What other reforms are on the horizon that will draw on the same stores of social capital? These questions turn the tendency to ask about the distribution of financial capital (is there enough money . . . ?) or physical capital (do we have the materials and space . . . ?) or human capital (are our teachers trained . . . ?) to comparable questions about social capital.

As we develop our theory, we note that schools are representative of well-bounded social systems in which social processes are

critical to functioning (Bidwell 2000; Bidwell and Kasarda 1987; Hannan and Freeman 1984; Singh, House, and Tucker 1986; Wilkins and Ouchi 1983). Hence, it is not surprising that many organizational theories have been applied to schools (for reviews, see Bidwell and Kasarda 1987; Bolman and Heller 1995; Perrow 1986), from control theory (Callahan 1962) to contingency theory (e.g., Greenfield 1975) and new institutionalism (Meyer and Rowan 1977; Rowan 1995). Thus, findings from our study of schools should have implications for other organizations.

We focus on computer innovations (e.g., the Internet, educational software, and the digital camera) because there is strong pressure on schools to implement such innovations (Budin 1999; Cuban 1999; Loveless 1996; Norris, Smolka, and Soloway 1999; President's Committee 1997). Computer technology is a valuable innovation for schools to implement, either because it enhances productivity or because of strong institutionalized legitimacy (Rowan 1995).

Previous research on the diffusion of computers in schools has generally focused on the effects of three sets of factors on the adoption of computers. First, access to functional and reliable hardware and software and technical support was critical to implementation (Collins 1996; Cuban 1999; Loveless 1996; Zhao and Frank 2003; Zhao et al. 2002). Second, institutional factors, such as scheduling and types of school leadership, affected teachers' use of computers (Collins 1996; Cuban 2001; Hodas 1993; Loveless 1996; Sandholtz and Ringstaff 1996; Zhao et al. 2002). Third, and perhaps most frequently cited, were characteristics of the individual teacher, including the willingness and ability to use technology and pedagogical style (Becker 2000; Burns 2002; Gilmore 1995; Hadley and Sheingold 1993; Harris and Grangenett 1999; U.S. Congress, 1995).

A few studies have highlighted the importance of social contexts, social processes, and social support in teachers' uses of computers (Becker 2000; Sandholtz & Ringstaff 1996; Schofield 1995; Zhao et al. 2002), but there has been little theory or empirical research on the social processes that affect the implementation of computers within a school. Thus, in

the next section, we integrate social capital into a theoretical model of diffusion within organizations. We then use longitudinal, social-network data to assess empirically the effects of social capital on the implementation of computer technology in schools. In the discussion, we review the findings as examples of technology and organizations, draw implications for change agents, explore the theoretical emergence of social capital, and identify limitations.

DIFFUSION WITHIN ORGANIZATIONS

Rogers (1995:5) defined *diffusion* as “the process by which an innovation is *communicated* through certain channels over time among members of a social system” [emphasis added]. This definition features communication and reflects an individual-level innovation-decision process. In particular, Rogers’s process consists of an independent individual’s knowledge or awareness of an innovation, formation of an attitude toward the innovation, decision to adopt or reject the innovation, implementation of the decision, and confirmation of the decision process (see also Prochaska, DiClemente, and Norcross 1992).

The question, then, is how to elaborate the model to apply it to diffusion within organizations, such as schools. Rogers (1995:chap. 10) presented a brief history of the study of diffusion within organizations. Initially, researchers simply applied the model of the individual to the organization. Then, they included uniquely defined organization attributes (e.g., size, centralization, and complexity) that affect innovation. Next, they moved to a focus on implementation in an “explosion” of studies in the 1980s and 1990s and generated a new model of the processes through which an organization implements an innovation. For example, Rogers’s intraorganizational model includes agenda setting, matching an innovation to the agenda, redefining-restructuring, and clarifying and routinizing. But note that action is specified essentially at the organiza-

tional level—the organization (i.e., the members acting as a collective) sets an agenda, matches, and so forth. Like other such models (e.g., Leonard-Barton 1988), Rogers’s model has a managerial focus in which the organization decides to adopt an innovation and then must go through a roughly linear process to implement it.

Although the process that Rogers (1995) described may apply to manufacturing organizations with simple hierarchical decision-making structures (such as the Minnesota Mining & Manufacturing company studied by Van De Ven 1986), it may not apply to organizations, such as schools, in which decision making is complex (Etzioni 1961; Hage 1999). In these organizations, it is not a simple matter of making a collective decision to adopt and then implement an innovation. Instead, the process is more one of diffusion of innovation within the organization, since each actor has some autonomy to make his or her own decision partly in response to the ideas, information, and other social forces to which he or she is exposed.¹

To understand the diffusion process within organizations, we revisit Rogers’s (1995) individual-level model of diffusion and modify it to include the unique social processes that apply to members of a common organization. First, members of an organization derive important benefits from the organization, including social and psychological rewards, access to resources, information, and status. Therefore, they can exert social pressure on each other by sanctioning the failure to conform through mild detachment (i.e., leaving a member “out of the loop”) to complete ostracism (Ajzen and Fishbein 1980; Ibarra 1993). Note that actors may apply social pressure to other members of their organization to coordinate efforts, protect internal political positions, or direct organizational resources to support the innovation. Thus, social pressure within an organization goes beyond the mere interdependence of action that can apply, for example, to members of a system who adopt innovations in communication (see Valente 1995).

Second, members of an organization share the fate of the organization (see Portes and Sensenbrenner’s, 1993, discussion of bound-

ed solidarity). Therefore, they are more likely to help other members implement an innovation that improves their common fate. Of course, the formal organizational chart may designate a centralized department that is responsible for supporting technological innovations (Attewell 1992), but much help still comes from the informal organization (Aiken, Bacharach, and French 1980; Ibarra 1993; Kanter 1983). This help is critical for implementing complex innovations, such as new software or other computer technologies that are context specific (Eveland and Tornatzky 1990).

Informal help and social pressure can be combined under the general theoretical framework of social capital, which we define as the potential to access resources through social relations (Bourdieu 1986; Coleman 1988; Putnam 1993; for recent reviews, see Lin 2001; Portes 1998; Woolcock 1998).² An actor who receives help that is not formally mandated draws on social capital by obtaining information or resources through a social relationship or obligation. An actor who exerts pressure also draws on social capital by using the threat of detachment or ostracization to direct another's behavior.

The effects of social capital can be understood relative to a full model of intraorganizational diffusion, as depicted in Figure 1. First, note that for complex innovations, individuals do not simply implement or not. Because complex innovations have a variety of applications and uses (Bayer and Melone 1989; Yetton, Sharma, and Southon 1999), implementation should be defined on a continuum. In the figure, different baseline levels of implementation are depicted by the active, expert computer user, on the left, versus the hunt-and-peck novice, on the right. The other factors are understood to affect change in use along the continuum.

Although the focus here is on social capital and other network processes, it is important to include effects that have been identified in the literature (Bayer and Melone 1989; Wolfe 1994; Yetton et al. 1999). To begin, organizations affect members through job conditions, including location in the division of labor. For example, in high schools, members of English departments may be more inclined to imple-

ment new word-processing programs than may others, or in businesses, members of sales departments may be most inclined to implement new pricing software. In Figure 1, job conditions are represented by the boxes of alternating dashes and dots around each actor.

Implementation may also be affected by changes in job conditions, defined as job stress. Stress increases uncertainty and hence the demands on resources, accentuating immediate barriers to implementation. Thus, actors who experience considerable job stress may be less inclined to implement innovations. Job stress is depicted in Figure 1 via the jagged lines that connect the organization to each actor's job conditions.

The engineering approach to implementation emphasizes technical characteristics of the innovation (see, e.g., Ramamurthy & Premkumar 1995) or the interaction of technology and task (e.g., Cooper & Zmud 1990). In Figure 1, it is depicted in terms of the dotted lines pointing from Technology Resources to the computers used by the expert and novice.

In the literature on diffusion (Bayer and Melone 1989; Rogers 1995; Wolfe 1994; Yetton et al. 1999), the critical human factor that affects implementation is the individual's perceptions of the technology, particularly the perceived potential of the technology (this factor is consistent with the effects of the willingness to use and apply technology and pedagogical style on implementation found in the educational literature cited in the introduction). Traditional diffusion is depicted in Figure 1 via the dashed line from the mouth of the expert to the perceived potential (within the thought bubble) of the novice. Thus, although traditional diffusion is conveyed through communication, its effects on the use of computers are mediated by actors' perceptions of the value of technology.

Perceived potential can also be influenced by exogenous institutions (Meyer and Rowan 1977) regarding technology (e.g., societal tendencies to adopt certain platforms or to attribute more value to some uses than to others). The effect of institutions is depicted in the upper corners of Figure 1 via waves that permeate the organizational boundary

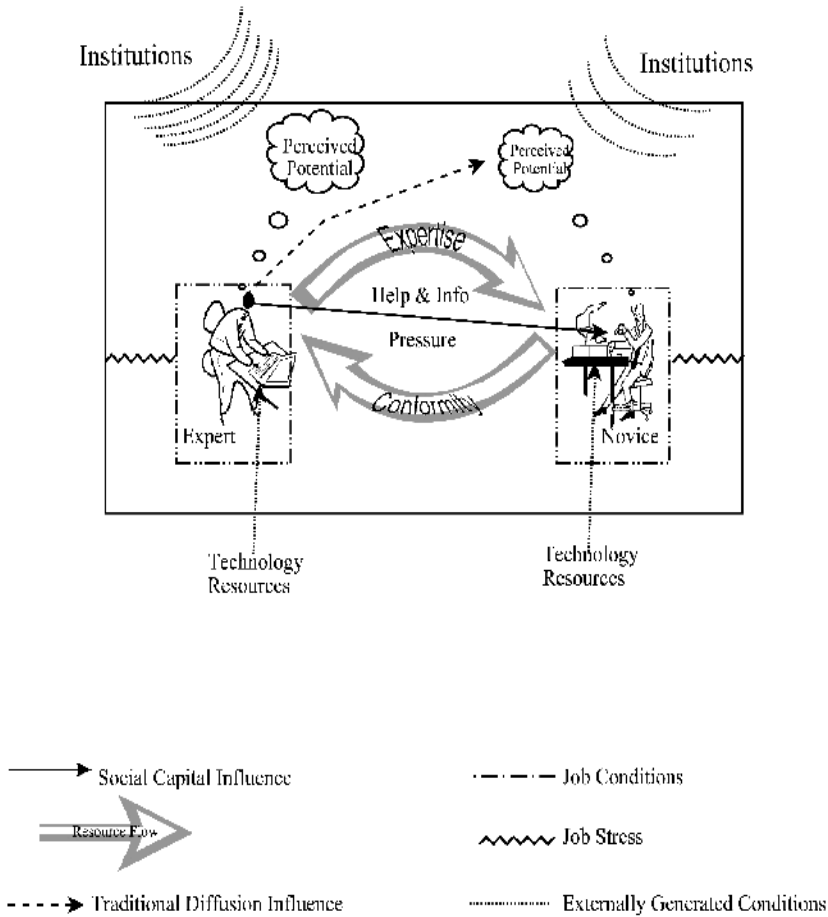


Figure 1. Social Capital and the Implementation of Innovation Within an Organization

and then approach the actors' thought bubbles. Furthermore, the effects of institutions can be indirect, since an organizational member who responds to an institution can then influence the potential of technology perceived by another. Hence, although institutions can affect each individual independently, institutions can be transmitted and filtered by the intraorganizational networks of traditional diffusion.

Social capital processes are also manifest through interactions. In particular, the expert user on the left in Figure 1 may provide information and help to the novice on the right, as well as apply social pressure. For example, in commenting on how she would respond to a non-computer user in her school, one teacher in our study indicated that she was inclined to apply social pressure ("You need to try and start experimenting"), as well as support

("Let them know they're not alone"). A critical point is that the effects of social pressure and access to others' expertise do not depend on changes in perceptions about the value of computers. Thus, the solid arrow in Figure 1 representing social capital effects points directly to the novice's behavior.

Although information, help, and social pressure are most likely to flow from those with greater expertise to those with lesser expertise, the flow of social capital is reciprocal, as indicated by the gray shaded arrows in Figure 1. When resources flow, in the form of help, they do so from those with greater expertise to those with lesser expertise.³ On the other hand, the actor who implements an innovation in response to social pressure provides a resource, in the form of conformity, to other members of the organization who have already implemented at higher levels.

The reciprocal flows of social capital within the organization are integral to the transition from individual, microlevel action to the macrobehavior of the organization. Each actor is a potential "other" for the rest of the organization. The language is often telling, since obligations of latent social capital are often attributed to an unspecified *they*: "They need so much help" or "They're pressuring me to use technology more." As another teacher in our study described her response to computer technology:

Very frightened to use it [technology], but you know, some of the people in the building are very much pushing us, and the peer pressure, in a way, to try new things, and it's sort of like I'll try it if you support me in this, so we try more things until we get hooked ourselves on this. And then we try to hook more teachers into it.

As this teacher was subject to and then a conduit for social pressure, she was affected by, and then became part of, the organizational culture.

Overall, Figure 1 locates multiple levels of constructs that affect the implementation of an innovation relative to the organizational boundary. Institutions and technology (other than that produced by in-house research and development) originate from outside the organization. The organization directly and structurally affects its members through job conditions and job stress. Most important, interactions within organizations, including those of traditional diffusion and social capital, are key processes that contribute to informal organizational culture and thus to the organization as a social entity.

Plan of Analysis

In the next section, we present a study of the implementation of computer technology in schools to evaluate many aspects of our model. The focal action in Figure 1 is the implementation of computers, representing the general implementation of innovation. Therefore, we identified the use of computers as our outcome. Our theory then applies to how other characteristics, such as job conditions and social capital, affect the implementation of innovations. Correspondingly, we

treated measures of these other characteristics as predictors in our analyses.

Because our theory integrates previous theories and introduces the construct of social capital in the diffusion of innovation, part of our empirical analyses were exploratory. Thus, we obtained multiple measures for each theoretical construct and describe the relationship between each measure and computer use with correlations (partialled for school membership to account for unique school characteristics). We then partialled for *expertise*, allowing us to assess effects on *new* computer use. Finally, we used regression simultaneously to estimate and account for multiple effects on computer use, ultimately reporting a parsimonious model with high explanatory power that represents each theoretical construct.

IMPLEMENTATION OF COMPUTER TECHNOLOGY IN SCHOOLS

Sample and Design

We conducted our study in six schools in three states. The schools were chosen because they were believed, through other research, to be attempting to implement computer-related innovations.⁴ Innovations ranged from providing laptop computers to all students and infrared access in all classrooms to software for facilitating open communication to use of the Internet as the exclusive source for technology (e.g., software, data, and graphics).

Two states were in the northern Midwest, and the third was in the Southwest. Two of the schools served kindergarten through the fifth grade, one served the second and third grades only, one served kindergarten through the eighth grade, one served the sixth through the eighth grade, and one was a high school (for which only two strands, or schools within a school, were sampled). Faculty sizes ranged from 15 to 80. The student composition ranged from one school that was upper middle class (10 percent were entitled to free lunches) to one that was

mostly lower class (95 percent were entitled to free lunches), and the racial compositions included a school that was 95 percent white, two that were 95 percent Hispanic, and one that was 95 percent black.

From January to May 2000, we interviewed at least six teachers in each school, as well as each principal. From November 2000 to May 2001, we conducted at least six more interviews per school, about half of which were reinterviews of original informants. Both times, a simple protocol was used ("How do you use computers?" "How do you make decisions about what to use?" "What is the social context in which you make those decisions?"). These interviews provided basic phenomenological data regarding computer use and informed the development of a questionnaire to assess teachers' use of computers, perception of the potential of computers, background information, and the like.⁵ The questionnaire also included sociometric questions regarding professional discussions, closest colleagues, providers of help in using computers, and with whom teachers talked about computers. Thus, each respondent indicated others who were close colleagues, helpful, and so forth. The respondents also indicated frequency categories for talk and help.

After conducting the first round of exploratory interviews, we surveyed teachers⁶ in eight schools in spring 2000 (March to May), defined as Time 1. The original sample size was 230. We returned for a second survey in spring 2001 (March to May) to six of the schools, defined as Time 2. (One school at Time 1 was not formally recruited but voluntarily completed surveys without compensation and chose not to volunteer at Time 2. The principal of another school indicated that she felt too much external pressure to ask her teachers to participate in the survey a second time.) To achieve high response rates, schools were offered \$400–\$500 compensation for a response rate of 85 percent or higher.⁷ The survey was administered at staff meetings on most occasions, with repeated follow-ups with principals or contact with teachers to identify and solicit teachers who had not yet responded. This contact was especially necessary to obtain information from teachers who

were less socially engaged in their schools and therefore less likely to participate in a school-based survey. For each wave, response rates were greater than 70 percent in each school except one (which was 50 percent at Time 1 and 35 percent at Time 2). Ultimately, we conducted analyses on 143 teachers for whom we had data at Time 2 and could obtain a measure of expertise.

Measures

Implementation of Computer Technology

We adapted the primary measure of innovation implementation from the diffusion-of-innovation literature (see, e.g., Rogers 1995; Tornatzky and Fleischer 1990; Wolfe 1994) to apply to teachers' computer use. In particular, we measured use not in terms of gross percentages of time that teachers and students used computers, but in terms of the number of occasions on which teachers used computers for each of five primarily educational goals and activities. Thus, we defined use by the sum of teachers' responses to a set of items measured at Time 2 beginning with the stem, "I use computers to help me . . .," completed by "teach the required curriculum," "introduce new material into the curriculum," "model an idea or activity," "connect the curriculum to real-world tasks," and "motivate students." The responses were on a 5-point scale (recoded to represent the number of days per year: daily = 180, weekly = 40, monthly = 9, yearly = 1, and never = 0). Means ranged from 27 to 58, with standard deviations ranging from 47 to 71 ($\alpha = .91$; items listed in order of correlation with the total from the highest to the lowest). Although these items were based on teachers' reports, they at least measure teachers' behaviors, which ultimately must be the link between any innovation and educational outcomes. Furthermore, the teachers were likely to be reliable informants of their own behaviors (cf. Bidwell, Frank, and Quiroz 1997).

Our dependent variable, computer use, is a count of the number of occurrences. It is not surprising that the distribution had a large positive skew, with a few teachers reporting extreme amounts of use. Correspondingly, we included the natural log

of computer use in the descriptive statistics (as well as the original metric) and used the log version in reporting correlations and regression models.⁸

Access to Expertise Through Help and Talk

The manifestation of social capital depends on the extent and quality of the resource that is provided. Regarding computer technology, the quality of the resource depended on the expertise of the teacher who provided help or with whom others talked about computers. Of course, expertise can be partly defined by knowledge of an innovation, but recognizing the complexity of teaching as a task and of computers as an innovation, expertise must also consist of understanding how to apply computers to teaching. Thus, our measure of expertise began with the amount of time that teachers used computers for their own purposes (e.g., to teach the required curriculum) and students' purposes (e.g., to help students communicate) at Time 1. The scale for these measures ranged from strongly disagree to strongly agree.⁹

We then augmented the measure of expertise with information from Time 2, including the total number of applications with which the teacher was familiar and the extent to which the teacher reported being able to operate computers and how confident the teacher felt with computers. An overall composite was made by taking the average of standardized versions of each variable ($\alpha = .76$). Using the Time 2 data increased reliability and provided information for teachers who did not respond to the Time 1 survey ($n = 57$). The supplemental items generally referred to the expertise of the teacher but did not directly include measures of the extent to which the teacher used computers at Time 2 (thus avoiding problems of circularity, or endogeneity, and problems of estimation; see Marsden and Friedkin 1994).¹⁰

Social capital is observably *manifest* when one actor allocates resources to another through interaction that is not formally mandated. Correspondingly, we measured two types of interactions through which resources could be conveyed. First, each teacher listed the others who had provided help to use computers. Since this type of help is rarely

mandated in schools, occurrences of it are evidence of the manifestation of social capital. Second, each teacher indicated with whom she or he talked about computers. Admittedly, engaging in talk is less demanding of a provider than is providing help. But teachers convey information through talk, and information is a resource of social capital (Arrow 1979; Sandefur and Laumann 1998).

To obtain a social-capital measure of expertise accessed through help, we multiplied the frequency (daily = 180, weekly = 40, monthly = 9, yearly = 1) with which a teacher i obtained help from another, i' , by the expertise of i' . We then summed across all others:

$$\text{Access to expertise through help}_i = \sum_{i' \neq i}^{n-1} (\text{help}_{ii'}) \times (\text{provider's expertise}_{i'}) \quad (1)$$

where $\text{help}_{ii'}$ is the extent to which teacher i reported (at Time 2) receiving help with computers from teacher i' . Thus, the right-hand side defines an independent variable representing a network effect (Marsden and Friedkin 1994). Moreover, the right-hand side draws on the comprehensive network data to include the two components of social capital: a resource (expertise) and an interaction (help) through which the resource is provided.

We note that the measure, as defined by Equation 1, is limited because it does not account for the provider's ability to convey expertise. Just as good teachers must have knowledge of pedagogy, as well as subject matter, so good helpers must know how to convey their expertise to others. Although we did not directly measure the ability of each teacher to convey expertise, we used as a proxy the amount that others received help from a given teacher (i') at Time 1 and Time 2. Our reasoning is that those who were frequently listed by others as providing help must have been reasonably good at doing so. Hence, our new measure is

$$\text{Access to expertise through help}_i = \sum_{i' \neq i}^{n-1} (\text{help}_{ii'}) \times (\text{provider's expertise}_{i'}) \times (\text{amount of help provided to others}_{i'}) \quad (2)$$

Thus, the extent of expertise accessed through help depends on the provider's ability to convey help.

Next we generated a comparable measure based on talk as interaction. That is,

$$\text{Access to expertise through talk}_i = \sum_{\substack{t=1, \\ i' \neq i}}^{n-1} (\text{talk}_{it}) \times (\text{provider's expertise}_{i'}) \times (\text{amount of help provided to others}_{i'}) \quad (3)$$

where talk_{ij} is the extent to which teacher i reported (at Time 2) talking to teacher j about computers.

The measures of expertise accessed through help and talk were highly correlated, at .87. Therefore, we combined the values into a single measure of expertise accessed, either through help or talk:

$$\text{Access to expertise through help and talk}_i = z[(\text{Access to expertise through help})_i] + z[(\text{Access to expertise through talk})_i] \quad (4)$$

where z indicates that the variable was standardized with a mean of zero and a variance of 1.¹¹ We then reduced the positive skew by adding .95 to make all values positive and taking the natural log. Ultimately, the coefficient for this measure represents the flow of social capital from expert to novice in Figure 1.

Social Pressure to Use Computers It was not feasible to ask the teachers directly about others who exerted social pressure. The teachers, like members of most organizations, were reluctant to identify specific others who had exerted pressure, with its negative connotation. Therefore, we asked, more generally, the extent to which the teachers agreed with four statements at Time 2 ("Others in this school expect me to use computers," "Others in this school encourage me to use computers," "Knowing about computers increases opportunities for collaboration at—,—" and "Using computers helps a teacher become integrated into—"). All the variables were measured on a 4-point Likert scale, ranging from strongly disagree to strongly

agree ($\alpha = .66$; items in the previous sentence were listed in order of their correlation with the total, from the highest to the lowest). The four statements measure perceived social pressure, including direct pressure (e.g., expectation), as well as encouragement and opportunities that can serve as indirect pressure. Ultimately, the coefficient for this measure represents the flow of social capital from a novice to others.

Own Expertise Following the logic of human capital (see Bourdieu 1986 for a comparison of human and social capital), a teacher can access his or her own expertise to implement computers. Furthermore, because a teacher's own expertise is essentially a baseline measure, controlling for a teacher's own expertise allowed us to make causal inferences more confidently from the estimated coefficients for other factors. For example, as is postulated here, actors who have access to others' expertise are more likely to implement innovations, but this likelihood may be obscured by the fact that those with the most inclination to implement may already have expertise and thus may not require help from others. Therefore, by controlling for own expertise, we could identify the unique effect of access to others' expertise. The same variables used to measure a provider's expertise were used to measure own expertise. Of course, for own expertise, the values were based on responses from the same subject as the dependent variable.¹²

Perceived Potential of Computers The traditional diffusion model operates through actors' perceptions of technology, as indicated by the thought bubbles in Figure 1. Drawing on what Wolfe (1994) referred to as relative advantage, one of the most important factors found by Tornatzky and Klein (1982), we developed two measures of the perceived potential of computers on the basis of responses at Time 2. For the first, the items matched those of our dependent variable, use of computers, but began with the stem "Computers can help me . . ." and were completed by "introduce new material into the curriculum," "connect the curriculum to real-world tasks," "teach the required curricu-

lum," "motivate students," and "model an idea or activity." Responses were on a 4-point Likert scale, ranging from strongly disagree (1) to strongly agree (4). The means ranged from 3.15 to 3.38, and the standard deviations ranged from .56 to .65 ($\alpha = .90$; items listed in order of correlation with the total, from the highest to the lowest). Because the original variable had a negative skew, the measure used in the correlations and regression analyses was based on the $-\log(5 - \text{original value})$.

For the second measure of perceived potential, we recognized that teachers may perceive the potential of technology more for their students than for themselves (Cuban 1999). Thus, we developed a measure of perceived potential of computers for students' use. These items began with the stem "Computers can help students . . ." and were completed by "communicate," "engage new material," "explore alternative ways of thinking," "collaborate," "engage in higher-order thinking," and "think critically." Responses were on a 4-point Likert scale, ranging from strongly disagree to strongly agree. The means ranged from 3.23 to 3.40, and the standard deviations ranged from .54 to .62 ($\alpha = .94$; items listed in order of correlation with the total, from the highest to the lowest).

Resources for Computing Of course, the resources define the technology to which one has access, as is shown by the type of computers used in Figure 1. We measured the adequacy of technical resources in terms of the percentage of times a teacher reported encountering significant technical difficulties with computers that limited use (less than 25 percent = 1, 26 percent to 50 percent = 2, 51 percent to 75 percent = 3, and more than 75 percent = 4). We also created a composite of the perceived adequacy of physical resources from the following statements: "The computer resources in my room are adequate," "I would like access to more hardware" (reverse coded), and "I would like access to more software" (reverse coded). Each response was obtained at Time 2 and was based on a 4-point Likert scale, ranging from strongly disagree to strongly agree ($\alpha = .71$). For the regression analyses, we took the natural log

because the original variable had a positive skew.

We also measured perceived adequacy of organizational support for computers, based on the mean of responses to three items: "I have adequate support to use computers in my classroom," "It is easy to introduce new software at—," and "I have adequate support for new things I am asked to implement." Each response was obtained at Time 2 and was based on a 4-point Likert scale, ranging from strongly disagree to strongly agree ($\alpha = .72$).

Job Conditions Job conditions define unique contexts that affect the true and perceived value of the technology and the unique obstacles to implementing the technology. These conditions are represented by the box of alternating dashes and dots around each user in Figure 1. Measures of job conditions included class size, grades taught (including separate indicators for teachers of multiple or unknown grades), and years in school. We used the log of years in school in the correlation and regression analyses because the original measure was positively skewed.

Job Stress Job stress can demand immediate resources, distract attention, and induce burnout, all of which may affect an individual's capacity and intent to implement innovations. Job stress is shown by the jagged line (i.e., shaking the users) in Figure 1. Measures of job stress included perceived workload (minimal = 1, engaged = 2, busy = 3, or overwhelmed = 4), whether the grades or subjects were new,¹³ and perceived changes in emphasis on standardized tests (the latter responses were on a 5-point scale, ranging from "much less" to "much more" than the past year). Items were treated separately because no combination had an internal consistency higher than .7.

Background Of course, people of different backgrounds may have different propensities to use computers. We included fixed effects (i.e., dummy variables) for a teacher's gender and race-ethnicity.

School Teachers were nested within schools, thus constituting nested or multilevel data

(Bryk and Raudenbush 1992). The schools differed in the populations they served, their configurations, their architecture, their leadership, their institutional histories, and their relationships to their districts. These characteristics all undoubtedly affect the diffusion of any innovation. But estimation of school effects was beyond the range of this study. Because our theory focuses on intraorganizational processes and we had only six schools in our final sample, we controlled for school effects using a set of dummy variables (that is, we treated schools as fixed, not random, effects, as in multilevel models). Thus, any characteristic associated with the school, from student composition to the general availability of hardware, was captured in the unique effect for each school. To conserve degrees of freedom, we used two dummy variables delineating schools that differed substantially from the others.¹⁴

Institutions

As was described in our introduction, all the schools in the study were exposed to common, general societal-level institutions to implement technology. Thus, there is little variation in exposure to societal institutions. Furthermore, we controlled for unique state or district institutions through the dummy variables designating each school described earlier. Finally, following the new institutionalism, our model postulates that institutions have their effect by altering actors' perceptions, which are included in our model. Nonetheless, the direct effects of institutions were essentially untested, since we attended to intraorganizational diffusion.

RESULTS

The means for each of the variables are given in the second column of Table 1. On average, the teachers reported applying computers to 196 purposes per year (although any given use could have more than one purpose). Regarding measures of social capital, access to expertise through talk and help had a mean of -1.43 and a standard deviation of 1.67, although the metric is difficult to inter-

pret because expertise accessed through talk and help were each defined by the multiplication of three components. The teachers tended to agree with statements regarding perceived pressure to use computers (mean = 2.96).

The teachers' mean responses to statements regarding the perceived potential for teachers' use of computers was slightly greater than agree (mean = 3.25) and similar for students' use (mean = 3.30), indicating that the teachers placed a high value on the potential of computers. Regarding technology resources, on average, the teachers reported significant technical problems 25 percent to 50 percent of the time (mean = 1.54), suggesting a serious limitation even in these schools, which were selected partly for their intentions to use computers. The teachers were inclined to disagree with statements regarding the resources that were available for computers (mean = 1.82), indicating that they perceived their resources to be limited, although they were almost neutral in rating their organizational support (mean = 2.59).

Regarding job conditions, the average class size was about 22. The mean grade level was between the fourth and fifth, and about half the teachers indicated teaching multiple grades via shared classrooms or special assignments. The average teacher had been in his or her school for slightly less than 7½ years, with considerable variation.

Regarding job stress, the teachers tended to describe their workloads as busy (mean = 3.13), with 16 percent teaching new grades and 11 percent teaching new subjects. The average teacher indicated that there was more emphasis on standardized tests in 2000–01 than in 1999–2000 (mean = 3.86). Thus, there was already increasing emphasis on standardized tests, at least in this small sample, before the "No Child Left Behind" policy was implemented. Finally, regarding background, 27 percent of the teachers were men, and 43 percent were white (this may be an unusually low percentage of white teachers, but there were many minority teachers in the schools that served primarily Hispanic students and the one school that served primarily black students).

The correlation of each variable with

Table 1. Descriptive Statistics for Factors Related to the Use of Computers

Factor	Mean	SD	Correlation with Log of Computer Use at Time 2, Partialling for School	Correlation with Log of Computer Use at Time 2, Partialling for School and Own Expertise
Occurrences of computer use (as reported by the teacher)	1.96	1.251	—	—
Log of occurrences of computer use (as reported by the teacher)	4.26	1.81	—	—
<i>Social Capital</i>				
Access to expertise through help and talk	1.43	1.67	.28	.26
Perceived social pressure to use computers	2.96	.49	.36	.28
<i>Perceived Potential</i>				
Perceived potential of computers for teachers' use	3.25	.51	.34	.26
Perceived potential of computers for students' use	3.30	.51	.19	.08
<i>Technology Resources</i>				
% of time that the teacher had significant technical problems using computers	1.54	.80	.00	.07
Perceived adequacy of physical resources	1.82	.65	.14	.22
Perceived adequacy of organizational support	2.59	.68	.16	.07
<i>Job Conditions</i>				
Class size	21.66	6.44	-.25	-.21
Grade ^a	4.71	2.55	.00	-.06
Teaching multiple grades	1.54	.50	.10	.10
Years in school	7.35	6.46	.03	.07
<i>Job Stress</i>				
Workload	3.13	.58	-.10	-.07
Teaching a new grade	.16	.37	.02	.10
Teaching a new subject	.11	.32	.04	.10
Perceived changes in emphasis on standardized tests	3.86	.86	-.15	-.06
<i>Background</i>				
Male	.27	.45	-.04	-.03
White	.43	.50	.08	.00

^an = 60; only those reporting a single grade.

reported use of computers at Time 2, partialling out school, is given in the fourth column of Table 1. The social-capital partial coefficients were moderate: .28 for access to expertise through help and talk and .36 for perceived social pressure to use computers. The traditional diffusion measure of perceived potential for teacher's use had a coefficient of .34, while the perceived potential for students' use had a coefficient of .19. The difference is not surprising, since perceived potential of teachers' use aligns most with teachers' use of computers.

Perceived adequacy of resources and perceived organizational support both had moderate coefficients (.14 and .16, respectively). Of the remaining factors, class size had a coefficient of -.25, and perceived changes in emphasis on standardized tests had a coefficient of -.15. No other coefficients were greater than .10.

Many of the coefficients that were partialled only for school are consistent with relationships reported in the literature (e.g., Rogers 1995; Tornatzky and Fleischer 1990; Wolfe 1994). But it is important to note that other studies have typically not controlled for an individual's own expertise, and any relationship with computer use may be spurious, attributable to expertise. Hence, in the last column of Table 1, we report the correlation of each variable with reported use of computers at Time 2, partialling out school and expertise. Many of the largest correlations are reduced (access to expertise through talk and help, perceived pressure to use computers, perceived potential of computers for teachers' use, perceived potential of computers for students' use, perceived adequacy of organizational support, class size, and perceived increased emphasis on standardized tests). Therefore, some of explanatory power of each of these measures should more rightly be attributed to a teacher's expertise. For example, although those who perceive organizational support to be adequate use computers more, their greater use may be attributed to their expertise. The only correlation that increased once we partialled for expertise was perceived adequacy of physical resources, reflecting a suppression effect. Those with greater expertise actually perceive

resources to be less adequate (perhaps because they are more demanding). Thus, the adequacy of physical resources has a larger effect on computer use within levels of expertise than across the whole sample.

Partialling for school and expertise, we found that the job-conditions coefficient with the largest magnitude was class size (-.21). None of the other measures for job conditions (grade, teaching multiple grades, years in school), job stress (workload, teaching a new grade, teaching a new subject), or background (gender, race) had partial correlations with computer use above the magnitude of .10. Thus, although there were general theoretical reasons to believe that job conditions, job stress, and background could be related to the use of computers, the specific measures were neither statistically significant nor substantively meaningful in correlations that partialled for school and expertise or in the final model.

The results from the final regression for computer use are shown in Table 2.¹⁵ This model was chosen for its explanatory power (R^2 of .42), parsimony, and representation of theoretical constructs.¹⁶ The most important predictor was own expertise, with a standardized coefficient of .32. Access to expertise through help and talk was statistically significant at $p \leq .01$, and perceived social pressure to use computers was statistically significant at $p \leq .05$. Moreover, the standardized coefficients for the social capital measures (.21 and .16, respectively) were comparable to those of the perceived potential of computers (.18) and the perceived adequacy of resources (.19). In fact, the change in R^2 above a baseline model (controlling only for own expertise and schools) was .10 for the social-capital measures, compared to .08 for the traditional diffusion measures. Hence, the two social-capital measures explained slightly more variation in the use of computers than did measures of traditional constructs of the perceived adequacy of resources and the perceived potential of computers.¹⁷

Finally, teachers with large classes (job conditions) and who perceived an increased emphasis on standardized tests (job stress) were less likely to use computers. Both effects were small but statistically significant ($p \leq$

Table 2. Model for Log of Occurrences of Computer Use at Time 2 (N = 143; standard errors in parentheses)

Independent Variable	OLS Coefficient	Standardized Coefficient
Access to expertise through help and talk (social capital)	.23** (.09)	.21
Perceived social pressure to use computers (social capital)	.56* (.28)	.16
Perceived potential of computers for teacher use (perceived potential—traditional diffusion)	1.02* (.44)	.18
Perceived adequacy of physical resources (technology resources—traditional diffusion)	.90** (.33)	.19
Class size (job conditions)	-.04* (.02)	-.12
Perceived changes in emphasis on standardized tests (job stress)	-.34* (.17)	-.16
Own expertise	.71*** (.17)	.32
Intercept	5.24 (1.32)	
R ²	.42	
Adjusted R ²	.38	

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

.05). Thus, teachers' implementation of computers can be affected by incidental conditions locating them within their organizational context.

Regarding the effect of expertise accessed through help, one teacher explained (emphasis added):

A person helped us and answered questions we had about how to use the computer and how to . . . , how to use clip art and how to just do things that we wanted to do, that we didn't feel comfortable doing. So this person was very instrumental in getting . . . , getting me to feel more comfortable with my computer.

Consistent with the theory presented in the previous section, this comment indicates how the effects of social capital can bypass stan-

dard effects of diffusion, particularly those of resources and perceived potential; the teacher's emphasis was on comfort with the computer, not on the perceived value of the computer.

It is possible that the standard diffusion and social-capital mechanisms are redundant (suggesting negative interactions). For example, when teachers perceive that there is a high value in using computers, social pressure may be unnecessary. Similarly, when resources are adequate, access to others' expertise may have less value. Consistent with this conjecture, interactions between standard diffusion and social-capital measures were negative, although only the interaction of social pressure and perceived potential approached statistical significance.

DISCUSSION

We have included social capital in a theory of the diffusion of innovations within organizations. Members of an organization are likely to help and talk to one another because they share a common fate, and members of an organization can exert social pressure on one another because they affiliate with a common social system. Help, talk, and social pressure are not merely disjoint processes. Each plays off the other as organizational members generate, and draw on, social capital. Empirically, the effects of access to expertise through help and talk (measured with network data) and perceived social pressure to use computers were comparable to traditional diffusion effects associated with the perceived value of technology and the adequacy of resources.

We recognize that the effects of social capital are moderate. But social capital need not have dominating effects to be an important force for the implementation of innovations because social capital leverages expertise and social relations that are already in a system. Thus, social capital is readily available relative to the purchase of physical resources or attempts to change the potential value that actors perceive for technology, which can be expensive and time consuming. Furthermore, because social capital leverages existing expertise, it can theoretically apply to the implementation of any innovation for which there is already some expertise and favorable predisposition in the system. In fact, the effects of social capital may be easily overlooked in any given situation because they are ubiquitous (Burt 2000; Coleman 1988; Granovetter 1985; Portes 1998).

The function of social capital in intraorganizational diffusion helps us understand the transitions between the macrolevel social entity of the organization and the microlevel action of independent individuals. Theoretical explanations of the link between organizational culture and organizational-level implementation have not elucidated the underlying mechanisms and processes at the individual level (see, e.g., Amburgey, Kelly, and Barnett 1990; M. D. Cohen and Sproull 1995; Cook and Yanow 1995; Kotter and Heskett 1992; Siehl and Martin 1990). But we argue

that the organization establishes the context for sharing resources and social pressure that is targeted toward the implementation of an innovation. This function of the organization is in contrast to persuasion through individual-based communication that is targeted toward changes in perceived potential, as in the traditional diffusion model (Rogers 1995). Thus, our theory of social capital addresses how individuals draw on membership in a common organization to gain access to expertise and exact conformity to influence each others' implementation. Organizational culture is not neglected in the least (Bryk et al. 1998). Rather, the effects of organizational culture are realized when social capital is manifest.

Implications for Change Agents

One direct implication of our findings is that change agents may be able to draw on social capital to facilitate the implementation of innovations. For example, change agents could designate professional development time for organizational members to interact and share their expertise. Or change agents could strategically cultivate new expertise by supporting ambivalent actors to explore innovations and then share their knowledge. Using graphical representations of social structure (e.g., Frank 1996; Frank and Zhao 2004; McDonald 2002), change agents could strategically cultivate new relations through which innovations could diffuse more evenly. They may do so by relocating actors, encouraging interaction across departments, and the like.

Because social capital theory applies to the micro-macro transition, our findings also have implications for organizational-level action. In particular, if social capital is like other forms of capital, it is a fixed resource (Bourdieu 1986; Robison, Schmidt, and Siles 2002). For example, teachers may not have the time to help one another develop a new mathematics curriculum *and* implement a new after-school program. As a result, attempts to implement multiple innovations simultaneously may pit proponents against each other. Thus, although we tracked diffusion within schools empirically, our theory is consistent with those who call for implementation to be conceptualized at the

school, instead of the teacher, level (e.g., Bryk and Schneider 2002; Darling-Hammond and McLaughlin 1995; Frank and Fahrbach 1999; Lieberman 1995; McLaughlin and Marsh 1979).

Because social capital is local, an innovation that is effectively implemented in one organization may not be effectively implemented in another organization. For example, a school with computer expertise that is distributed evenly among teachers may effectively move from laboratory- to classroom-based computing because most of the teachers have a source of social capital on which to draw for help. On the other hand, a school in which computer expertise is held by a few socially marginal teachers may be more effective by formalizing support in a laboratory setting. This is just one example of how innovations cannot simply be scaled up and out (Coburn 2003) because implementation depends on the distribution of social capital.

Change agents should also attend to the job conditions and job stress of those who they hope will implement innovations. Regarding job conditions, our results suggest that the advantages of small classes, established experimentally (Finn and Achilles 1990), may be partly attributed to easing the implementation of an innovation. In particular, the demands of classroom management and unreliable technology (Cuban 1999) are greater in large classes, thus inhibiting the opportunity to experiment and innovate "on the fly." Conversely, our findings suggest that recent legislation that has emphasized standardized tests (the Elementary and Secondary Education Act/"No Child Left Behind Act of 2001") may impede the implementation of technological innovation by increasing job stress. Perhaps the tests require teachers to focus on forms of knowledge that are not easily supported by computers, or perhaps the high stakes associated with the tests make teachers averse to the risks of innovation. Generally, aspects of job conditions and job stress should be considered as constructs that affect implementation.

The Emergence of Social Capital

If change agents are to draw on social capital, then the next obvious question is, "Where

does social capital come from?" Frank (2001) found that teachers were more likely to help those whom they identified as close colleagues. Therefore, the flow of social capital was guided by social exchange. But Frank also found that those who identified with members of their schools as a collective were more likely to help others, regardless of close collegial relationships, thus facilitating the even distribution of resources throughout schools. This finding is consistent with those who have linked an overall sense of community to the efficient flow of resources within organizations and organizational effectiveness (see, e.g., Bryk et al. 1998). Hence, social capital emerges from direct social relationships and perceived links to a collective.

The mechanisms that Frank (2001) identified as generating social capital are almost inaccessible to change agents. It is difficult to generate new collegial ties or identification with a collective in the abstract. Then what is the role of the change agent? Recognizing that social capital accumulates through cyclical processes (Bryk and Schneider 2002; Putnam 2000), we should perhaps ask instead, "What are researchers and policy makers currently doing to facilitate or inhibit the cultivation of social capital?" To be sure, governmental policies can impede the cultivation of social capital by restricting and controlling behavior (Shedd and Bacharach 1991). Even well-meaning policies may limit social capital by formalizing exchange and therefore inhibiting opportunities to establish trust (Molm, Takahashi, and Peterson 2000). Most important, each demand placed on a school may drain the stores of social capital. Therefore, schools should be circumspect in the changes they attempt to implement, and change agents should be aware of other innovations that schools are implementing that may compete with their own and thus overdraw the stores of social capital.

Limitations and Extensions

Our findings were based on a small sample of schools. Although the students attending the schools varied considerably demographically, many types of schools and students were not represented in our sample. For example, our

sample consisted mostly of elementary schools, so we could not explore the extent to which the effects of social capital vary by level of school. Furthermore, we simply do not have enough degrees of freedom to estimate the extent to which our effects vary by average socioeconomic status, racial composition, and so forth.

Acknowledging concerns regarding the representativeness of our sample, we used a new index (Frank and Duke 2003; Frank and Min 2003; Min and Frank 2002), to calculate the robustness of our inference to potential alterations of the sample. In particular, we considered replacing half the sample with a hypothetical sample with a different partial correlation between predictors and outcomes (but with the same means and variances for all variables as for the observed cases). This index showed that the partial correlation between access to expertise through help and talk and use of computers would have to be less than .11 to alter the inference made from the final model. We may then consider the likelihood of observing a partial correlation of .11 and under what conditions access to expertise through help and talk would have a considerably smaller partial correlation than the observed value (.11 is about 1.5 standard errors below the observed value of .24, calculated from the regression coefficient in Table 2). Therefore, use of the index suggests that the inference regarding access to expertise through help and talk is moderately robust with respect to concerns about the representativeness of the sample.

Drawing on the same framework, the hypothetical partial correlation between perceived social pressure and use of computers would have to be less than .16 to alter the inference made from Table 2, whereas the observed correlation is .17. Thus, if half the sample were replaced with hypothetical cases for which the partial correlation between perceived social pressure and use of computers were only one one hundredth lower than the observed partial correlation, the overall inference would be altered. Clearly, such an alternative sample is reasonably likely, and it is easy to imagine a range of circumstances that could alter the inference.

Clearly, it would be valuable to extend our

study to a sample that is representative of a larger population and through which one could meaningfully explore variation in the effects of social capital by school characteristics, drawing on a multilevel framework (Bryk and Raudenbush 1992; Frank 1998). But our design features longitudinal data, sociometric items, and high percentages of the teachers in the targeted schools. To obtain such data requires a more focused effort than standard large-scale, representative surveys, which may be anonymous and may not place such high burdens on individual schools. Thus, in line with Bidwell's (2000, 2001) calls to attend to the micro social processes within schools, we have emphasized in-depth understanding of within-school social processes over national representativeness. Ultimately, of course, the two are not mutually exclusive, and we call upon the educational research community to focus more attention on gathering large-scale data that include the micro social processes of schools.

The study could also be extended by delving deeper into each school as a case. For example, Frank and Zhao (2004) described how collegial subgroups structured the diffusion process in schools. But what is needed is a deeper understanding of the interplay between the distribution of social capital and the roles that social capital plays in the diffusion process. This deeper understanding could apply particularly to how institutions permeate organizational boundaries and then are transmitted throughout organizations (omitted in our empirical analysis). For such analyses, one could draw more heavily on qualitative data to incorporate aspects of organizational history, decision making, politics, and so forth.

Our operationalization of social capital, as the potential to access resources through social relations, was intentionally narrow. As such, it may appear little different from social exchange (see, e.g., Blau 1967). But we specified the mechanisms of help and social pressure as social capital because, unlike social exchange, social capital emerges from the larger social context. In particular, teachers respond to social pressure and are inclined to help one another because they are members of a common social organization, the school.

Nonetheless, it would be important to link our conceptualization of social capital to other conceptualizations of social capital, such as an adaptation of Putnam's (2000) "civic participation," in the school setting.

In what other organizations and for what other innovations does our model of intraorganizational diffusion apply? We expect that the model applies to organizations in which decision making is complex and not the function of a centralized actor or set of actors. In such organizations, each member contributes to the pattern of diffusion, best understood through a model that includes the effects of interaction on individual action. Furthermore, we suspect that informal help and social pressure are more important when the technology is complex, as is the case for new software or computer technology. When technology is simple, implementation may be influenced by standardized, decontextualized sources.

In spite of these limitations, attending to the effects of social capital in intraorganizational diffusion generates important theoretical insights that were supported by our data. Social capital processes help us understand how organizations coordinate action without relying on formal authority or traditional influence processes, which have limited durability and/or immediacy. Thus, evidence of social capital has implications for those who hope to facilitate the diffusion of innovations within organizations. Finally, the language of the *social as capital* helps us to consider how informal help, talk, and pressure can accumulate but are fixed commodities at any given time. This point has critical implications for organizational change agents, who should not overtax social capital as they use it to leverage change.

NOTES

1. Fichman and Kemerer (1993) referred to diffusion within organizations as "assimilation," and Zmud and Apple (1992) referred to it as the "infusion" process, characterized by the integration of an innovation into the routines of the formal organization. In this article, we use *diffusion* to refer to the process through which innovation spreads and *imple-*

mentation to refer to the act of using an innovation.

2. We are aware that social capital has been defined in multiple ways, from Coleman's (1990:303) "definition by function" to Putnam's (2000:19) link to "civic virtue." The result is that social capital has become one of the most ambiguous terms in the social sciences (Portes 1998) and may lose any distinctive meaning (Hirsh and Levin 1999). Our definition is consistent with the emerging consensus among sociologists, as typified by definitions offered by Portes (1998:7) and Lin (1999:30–31). This narrower definition facilitates theory and operationalization, although in discussing limitations, we relate our definition to broader definitions and other sociological concepts.

3. We acknowledge that those with greater expertise may choose not to help others or may discourage others from using resources, preserving control over resources. But when actors engage in such competitive action, they undermine the goals of the common organization, to the extent that implementation of an innovation is beneficial to the organization (although actors may compete regarding some matters in some organizations; see Burt 2000). Since our theory is of intraorganizational diffusion, we emphasize the direction of effects that are generated by membership in a common organization.

4. In four of the schools, the third author and her colleagues evaluated the Urban Systemic Initiative sponsored by the National Science Foundation. This initiative emphasized constructivist teaching practices but included a technological component.

5. We also initially conducted a pilot study (with colleague Andrew Topper) establishing the reliability of several of the measures regarding computers (see Frank, Topper, and Zhao 2000).

6. The sample included administrators and support staff, but most respondents were teachers, and computers were implemented primarily in the classroom, so for the remainder of the article, we refer to the set of respondents as teachers.

7. Because of accounting constraints, schools were prepaid in June 2000 for their participation in 2000–01.

8. We also verified our results by applying Poisson regression to use of computers in its original metric to account for heterogeneous variances for a count variable, such as the purposes for which computers were used (the variance for a measure of count, such as use of computers, depends on the mean). We also corrected for overdispersion (the variance was approximately $4^{1/2}$ times the mean), with a scale parameter of 1.34 estimated by the ratio of the deviance to the degrees of freedom (McCullagh and Nelder 1989). Using this correction improves significance tests.

9. The scale was changed from Time 1 to Time 2 because there were strong response sets across items, with many teachers choosing a single value for all items at Time 1. This did not occur in our pilot data. The frequency scale at Time 2 evoked more variation in responses.

10. Use of computers at Time 1 was correlated about .6 with the total measure for those on whom we measured all components of expertise.

11. The 41 respondents who indicated that they neither talked to nor received help from anyone were assigned the score marking the bottom 1 percent, assuming that their access to social capital was extremely low.

12. Because the original scale of use of computers was different between Time 1 and Time 2 (see note 9) and because expertise was augmented with variables from Time 2, we could not construct and analyze difference scores (Allison 1990).

13. Approximately 40 percent of the teachers did not indicate whether they were teaching a new subject, possibly because, as elementary teachers, they were teaching all subjects every year. We assumed that these teachers were not teaching a new subject.

14. One dummy variable was associated with a predominantly Hispanic middle school that was lower than all others, and the other was associated with a predominantly Hispanic high school that was higher than all others.

15. The results from the ordinary least-squares (OLS) estimates were confirmed by those for a Poisson model. Each of the effects reported in Table 2 was statistically significant at $p \leq .05$ except perceived changes in emphasis on standardized tests and class size.

16. Although perceived changes in emphasis on standardized tests had only a partial correlation of $-.06$, it did enter our final model, whereas teaching multiple grades, teaching new grades, and teaching new subjects, each with a partial correlation of $.10$, did not enter our final model because their regression coefficients were reduced when other factors were controlled for.

17. One reviewer argued that traditional diffusion may be better measured by the *perceptions* of others with whom one interacts. We claim that perceptions of others should have their effect by altering ones' own perceptions and that interactions should have their effect by conveying resources; therefore standard diffusion processes are represented in our model. Nonetheless, we calculated a measure of exposure to others' perceptions using methods similar to those described for access to expertise through help and talk, replacing expertise with the other's average of perceptions of the value of technology from Time 1 and Time 2. We explored versions of exposure to others' perceptions including and excluding "amount of help provided to others" (interpreting it as a proxy for charisma). Consistent with the reviewer's suggestion, exposure to expertise was correlated with the log of computer use at $.20$ ($p \leq .05$) when own expertise and schools were controlled, as in Table 1. But none of the versions of exposure to others' perceptions was significant when it was added to the final model, with the magnitudes of standardized coefficients each less than $.03$. The coefficient for exposure to others' perceptions was most dramatically reduced once access to expertise through help and talk was included in the model, which is consistent with our argument that access to others's expertise affects behavior more than does exposure to others' perceptions.

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