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What is This?

Instructional Advice and Information Providing and Receiving Behavior in Elementary Schools: Exploring Tie Formation as a Building Block in Social Capital Development

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Few studies identify those factors that might account for the development of social capital. Understanding those factors associated with the existence of a social tie among actors in schools is important because absent social ties, individuals do not have access to social resources. We investigate social tie formation in schools focusing on advice and information providing and receiving in the two core elementary school subjects. Using a multilevel p_2 model, we examine the role of both formal organizational structure and individual characteristics in shaping advice and information providing and receiving about instruction. Our findings suggest that while the individual characteristics of race and gender are significantly associated with the

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formation of a tie, aspects of the formal school organization—grade-level assignment, having a formally designated leadership position, and teaching a single grade—are also significant and have larger estimated effects than individual characteristics. Formal organizational factors trump individual characteristics in the formation of a social tie, a necessary if insufficient condition for social capital development.

KEYWORDS: social capital, formal organization, social networks, teacher knowledge, mathematics, language arts

The construct of social capital has garnered much attention in sociology and in the sociology of education in particular. Building on and extending the work of Pierre Bourdieu (1986) and James Coleman (1988, 1990), scholars have theorized about social capital and empirically investigated its effects on valued outcomes. Though scholars focus on different aspects of social capital, the construct denotes real or potential resources for action that are attained *through relationships* (Bourdieu, 1986; Coleman, 1988; Lin, 1982, 2001). These resources take various forms, including material goods and services, trust, information, social support, social obligation, and social norms (Coleman, 1988; Inkpen & Tsang, 2005; Nahapiet & Ghoshal, 1998). Social capital differs from other forms of capital (e.g., human or physical capital) in that it is embedded in the relations among people. Both individuals and organizations can invest in, and benefit from, social capital (Ibarra, Kilduff, & Tsai, 2005).

Education research consistently points to the importance of social capital in enabling instructional reform and school improvement (Bryk & Schneider, 2002; Frank, Zhao, & Borman, 2004; Louis & Kruse, 1995; McLaughlin & Talbert, 2001; Rosenholtz, 1991; Smylie & Hart, 1999). In schools and school districts, social relations can be a source of various resources, including trust (Bryk & Schneider, 2002; Louis, Marks, & Kruse, 1996), expertise (Daly & Finnigan, 2010; Frank et al., 2004; Spillane, 2004), opportunities for joint sense-making (Coburn, 2001; Spillane, 2004), and incentives for innovation through peer pressure or sense of obligation (Spillane, 2004).

Much of the literature on social capital has focused on the organization of social relations, the resources embedded within social networks, and the returns from investments in social capital to both individuals and organizations (Lin, 1999). Research on schools, for example, has centered almost exclusively on the impact of social capital on valued school outcomes such as program implementation, instructional innovation, and student achievement (Bryk & Schneider, 2002; Frank et al., 2004; Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Leana & Pil, 2006; Penuel et al., 2010; Penuel, Riel, Krause, & Frank, 2009; Supovitz, Sirinides, & May, 2010).

The existence of a network tie, however, is neither "a natural given" nor "a social given" (Bourdieu, 1986, p. 249). Rather, these ties are a product of individual or collective action. Yet few studies focus on identifying those factors that might account for differences in, or the development of, social capital at the individual, group, or organizational level (Coburn, 2001; Small, 2010). "The real weakness is the lack of both theory and empirical work focusing on the causes of social capital. If we are going to change the level of social capital, we must have a coherent model of the formation of social capital and a body of empirical work that we trust about the formation of norms and networks" (Glaeser, 2001, p. 381). A step in this direction involves understanding those factors associated with the existence of a social tie among actors in schools because absent social ties, individuals do not have access to social resources.

In this article, we investigate social tie formation in schools focusing on advice and information providing and receiving in English language arts (ELA) and mathematics, the two core elementary school subjects. We examine the role of both formal organizational structure and of the individual characteristics of school staff in shaping advice and information providing and receiving about instruction. We begin by situating our work in the empirical and theoretical literature on social capital and, based on that, define working hypotheses that guide our analysis. Next, we describe our data collection and data analysis in 30 elementary schools in a midsized urban U.S. school district. We then present the results from a multilevel p_2 model (Van Duijn, Snijders, & Zijlstra, 2004; Zijlstra, Van Duijn, & Snijders, 2006). Our findings suggest that while the individual characteristics (e.g., race, gender) are significantly associated with the formation of a tie, the formal school organization is also significant and has larger estimated effects than individual characteristics. We conclude by discussing our findings and considering their entailments for research, policy, and practice.

Framing the Work

We anchor our article in theoretical and empirical work on social capital and social networks. We frame our work like this: Social ties among actors in schools are a necessary condition for social capital because in the absence of such ties, individuals do not have access to social resources. We use the empirical and theoretical literature on factors associated with the formation of social ties to frame our work analytically. We also justify our focus on advice and information ties, arguing that a key social resource accessed through ties, critical for knowledge development, is information and advice. People can develop new knowledge when they encounter new information or advice or when they combine different pieces of information and advice (Choo, 1998). We organize this section as follows: First, we consider the theoretical and empirical literature on tie formation in general, articulating

a series of working hypotheses that framed our analysis of the data. Second, we justify our focus on advice and information flow in elementary schools, arguing that advice and information are resources acquired through relationships and fundamental to knowledge development.

Social Ties: Individual and Organizational Considerations

As captured by the familiar adage "birds of a feather flock together," individuals are more likely to interact with others who are similar to themselves with respect to characteristics such as age, race, gender, education, and values (McPherson, Smith-Lovin, & Cook, 2001, p. 417) (see also Ibarra, 1992; Mollica, Gray, & Trevino, 2003; Monge & Contractor, 2003). Scholars use the term *homophily theory* to denote how individuals form ties with those who are like them, and the theory is supported by two hypotheses (Monge & Contractor, 2003). First, the similarity-attraction hypothesis suggests that people are more likely to connect with individuals with similar characteristics (Bryne, 1971). Second, the self-categorization theory suggests that individuals categorize themselves and others based on traits such as gender and race, using these categorizations to differentiate between similar and dissimilar others (Turner, 1987). The increased predictability of behavior and reduction in communication apprehension afforded by interpersonal similarities increases the likelihood that those who are alike will connect with one another (Ibarra, 1992). Various studies offer empirical support that birds of a feather tend to flock together, especially with respect to race/ethnicity (Mollica et al., 2003; Shrum, Cheek, & Hunter, 1988), education (e.g., Marsden, 1987), gender (Ibarra, 1992; Leenders, 1996), and age (Feld, 1982). Based on this literature, we anticipate that teachers will be more likely to interact with colleagues of similar race and gender:

> *Hypothesis 1a:* Teachers are more likely to provide or/and receive advice and information ties to (from) colleagues of the same race and gender.

We also expect that veteran teachers (i.e., teachers in later career stages) are less likely to receive advice and information from colleagues than new teachers (i.e., early career stage) (Moolenaar, 2010).

> *Hypothesis 1b:* More experienced teachers will be less likely to receive new advice and information from other colleagues.

Still, while the individual traits of organizational members may predict their ties with one another, social ties are embedded in organizations that make a difference to tie formation in that they bring people together who might not otherwise connect with one another. More important, the formal organizational structure is intended to enable and constrain interactions among organizational members (Blau, 1955; Blau & Scott, 1962). Aspects

of the formal organizational structure such as formally designated positions (e.g., school principal, teacher), organizational subunits (e.g., grade levels or departments), and formal organizational routines (e.g., faculty meetings, grade-level meetings) both enable and constrain interactions among staff.

Schools as organizations seek to cultivate knowledge flow in order to support and coordinate teaching practices. The formal structure assigns people to particular positions and to subunits that may more or less shape who they connect with, and they require participation in various organizational routines that bring organizational members into contact with some colleagues but not others (Adler & Kwon, 2002; Burt, 1992; Lin & Dumin, 1986; Spillane, Parise, & Sherer, 2011). In schools, for example, teachers typically work in grade-level or departmental subunits and tend to interact more frequently with colleagues in these subunits (Bakkenes, De Brabander, & Imants, 1999; Bidwell & Yasumoto, 1999; Bryk & Schneider, 2002; Daly, Moolenaar, Bolivar, & Burke, 2010; Rowan, 2002; Zahorik, 1987). The formal school organizational structure may support advice and information flow within grades or departments for several reasons, including that teachers teach the same subject or curricular material, prepare students for the same tests, participate in the same organizational routines (e.g., grade-level or department meetings), and/or their classrooms are located in close physical proximity to one another. Schools as organizations then enable and constrain the flow of advice and information by facilitating interaction among particular staff through assignment to subunits and formal positions (e.g., coach, assistant principal), participation in formal organizational routines, among other things. Expecting the formal organizational structure to shape the formation of new ties we hypothesize that:

> *Hypothesis 2:* School staff members with formally designated leadership positions are more likely to provide advice or information than staff without such formal leadership designations.
> *Hypothesis 3a:* Teachers who reported teaching across multiple grades are less likely to provide advice or information, compared with teachers who reported teaching one grade level or no specific grade level.
> *Hypothesis 3b:* Teachers will be more likely to provide or/and receive advice ties to (from) members of their grade-level teams than with other staff in their school.

With respect to Hypothesis 3b, there is also some evidence to suggest that communication patterns among teachers within schools vary depending on the grade level (de Lima, 2007).

Our interest in advice and information ties is chiefly motivated by their role in knowledge development. Formal professional development is one source of advice and information in schools. Policymakers and educational administrators use various policy levers (e.g., incentives, recertification requirements) to influence teachers' participation in professional development

(Desimone, Porter, Garet, Yoon, & Birman, 2002; Louis et al., 1996; Louis & Kruse, 1995; Penuel et al., 2009; Youngs & King, 2002). At the same time, teacher participation in professional development is also a function of individuals' disposition to learn and innovate and their openness to new ideas. Regardless of the motivation for participating, professional development is likely to be related to advice and information ties for at least three reasons. First, through participation in the same professional development workshop teachers can establish ties with colleagues with whom they might not otherwise form a tie (Coburn & Russell, 2008). Second, teachers who participate more in professional development are more likely to be known to their colleagues as sources of advice and information and/or more likely to be encouraged by school administrators to reach out and share their knowledge with colleagues. In many schools, school administrators support teacher participation in professional development on the understanding that they will come back and share the advice and information they gathered with colleagues (Frank et al., 2011). Third, teachers who are struggling in the classroom are more likely to be encouraged/required by school administrators to participate in professional development. These teachers may be more likely to seek out colleagues for advice and information in an effort to address their professional struggles. At the same time, colleagues may be more likely to provide advice and information to these teachers to help them address these challenges. Considering these three scenarios, we hypothesize that:

> *Hypothesis 4a:* Teachers are more likely to provide or/and receive[1] advice and information to (from) colleagues who report attending the same amount or more professional development.
> *Hypothesis 4b:* Teachers who report attending more professional development are more likely to receive advice and information from other colleagues.

We examined these two hypotheses separately for ELA and mathematics.

Social Ties, Social Capital, and Knowledge Development in Schools

We focus on advice and information ties because advice and information are fundamental building blocks for knowledge development, a critical ingredient for instructional improvement in schools (Elmore, 1996; Hill, 2004). Developing new knowledge involves complex cognitive process, and advice and information are key ingredients in this process (Bransford, Brown, & Cocking, 2000). In turn, advice and information are resources that can be acquired *through social relationships* that not only serve as conduits for advice and information but also enable joint sense-making—a critical component of knowledge development (Coburn, 2001; Daly & Finnigan, 2010; Frank et al., 2004, 2011; Kim, 2011; Spillane, 2004; Uzzi, 1997). Schools are knowledge-intensive organizations because of the complexity of the core technology of schooling—instruction (Cohen, 1988). This

complexity is in part a function of variability in student needs and the uncertainty of teacher-student relations (Barr & Dreeben, 1983; Bidwell, 1965; Bidwell & Kasarda, 1987; Cohen, 1988; Meyer & Rowan, 1977), competing and often conflicting demands on schools from a segmented institutional environment (Bidwell & Kasarda, 1987; Honig, 2006; Schmidt et al., 2001), disagreement about how best to teach, and the lack of homogeneity in teachers' preparation to teach (Lortie, 1975). Thus, the ongoing development of knowledge is critical in order that teachers can adapt their instructional practice to particular situations (Frank et al., 2011; Zhao & Frank, 2003).

Teachers can develop their knowledge through participation in professional development *and* through on-the-job interactions with colleagues (Parise & Spillane, 2010). Through participation in professional development, teachers encounter new information and get advice about teaching that can help them develop new knowledge that in turn may lead to change in instructional practice (Desimone et al., 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Hill, 2007; Little, 1993). While formal learning opportunities have taken center stage for policymakers, teachers also develop new knowledge through their interactions with colleagues on the job. On-the-job learning happens when organizational members interact, asking questions and getting information, observing colleagues, and giving and receiving feedback (Eraut, 2004; Eraut & Hirsh, 2007; Frank et al., 2004). On-the-job social interactions are associated with the transfer of information and advice, which is essential for professional learning and knowledge development (Frank et al., 2004; Reagans & McEvily, 2003; Uzzi, 1997).

While people *may* develop new knowledge through the exchange of information and advice, we acknowledge that not all information and advice leads to the development of new knowledge. Sometimes we encounter information or advice that is not novel. Further, even in situations where advice and information exchanges lead to new knowledge, this knowledge does not necessarily lead to changed, improved, or more productive practice. Sometimes people develop new knowledge but do not put this knowledge into practice. Further, misinformation and bad advice flows as easily as accurate information and good advice in social networks. As a result, people can develop knowledge that promotes doing things poorly (e.g., continue to teach mathematics in a way that results in most students failing) or doing the wrong things well (e.g., sell drugs on the street and make a profit).

Overall, social ties are a *necessary* if insufficient condition for social capital development. Yet, few studies examine those factors that might account for the existence of an advice or information tie among school staff. Framed by the working hypotheses outlined previously, we explore advice and information ties in the 30 elementary schools in our study. At the same time, in our analysis we allowed for the emergence of findings not captured by these hypotheses.

Student and School Staff Characteristics in 30 Elementary Schools in 2006–2007

	Minimum	Maximum	*M*	*SD*
Student				
Enrollment	354	870	540	132
African American	0%	90%	58%	29%
White	0%	70%	24%	24%
English language learners	0%	10%	1%	3%
Free or reduced lunch	10%	90%	59%	24%
School staff				
Full-time	89%	100%	96%	3%
Female	80%	98%	93%	5%
White	32%	93%	71%	17%
New after 2005	14%	62%	36%	13%
Years of teaching experience	9	19	13	3
Professional development in mathematics	1.58	3.60	2.01	0.38
Professional development in English language arts	1.73	2.84	2.20	0.28

Research Methodology

Sample

Data for this analysis are drawn from a larger study of school administration in one midsized U.S. public school district we name Cloverville. Staff members at each of Cloverville's 30 schools completed a questionnaire in the spring of 2005 and again in the spring of 2007.[2] Of the 1,356 elementary school staff members in the sample in 2005, 1,210 completed the survey for an 89% response rate, though the response rate ranged from 66% to 100% by school. Of the 1,436 elementary school staff members in the sample in 2007, 1,194[3] completed the survey for an 83% response rate, though the response rate ranged from 63% to 100% by school.

In the 2006–2007 academic year, on average, schools enrolled 540 students, ranging from a low of 354 to a high of 870 (see Table 1). On average, 58% of students were African American across the 30 schools, ranging from 0% to 90%; 59% of students received free or reduced lunch, ranging from 10% to 90%. In addition, three schools had more than 10% English language learners (ELLs). On average, 93% of school staff members were female across the 30 schools, ranging from 80% to 98% depending on the school. Seventy-one percent of school staff members were White, ranging from 32% to 93%. Over one-third (36%) of respondents in our sample were new staff members after the 2004–2005 school year, ranging from 14% to 62% depending on the school. The average number of years of teaching experience across the sample was 13 (see Table 1).

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Table 2
Grade Types and Change in Grade Levels Taught from 2005 to 2007

	Minimum	Maximum	*M*	*SD*
Grade types in 2007				
No grade level taught in 2007	0%	20%	9%	5%
Single grade level taught in 2007	18%	78%	63%	11%
Multiple grades level taught in 2007	8%	74%	28%	12%
Change in grades level taught from 2005 to 2007				
No previous ties				
Same grade level taught	3%	24%	10%	5%
Different grade level taught	21%	77%	42%	14%
With previous ties				
Same grade level taught	0%	30%	10%	7%
Different grade level taught	0%	30%	14%	7%
Total				
Same grade level taught	6%	39%	21%	9%
Different grade level taught	24%	86%	56%	14%

On average, 9% of respondents reported not teaching a class in 2007, ranging from 0% to 20% depending on the school. These staff members occupied full-time formal leadership positions, including assistant principal, ELA coordinators, and mathematics coordinators. Sixty-three percent of school staff reported being self-contained teachers teaching a single grade in 2007, ranging from 18% to 78% depending on the school. Twenty-eight percent of school staff reported teaching multiple grades, ranging from 8% to 74% depending on the school. On average across the 30 schools, 21% of school staff reported teaching the same grade level both in 2005 and 2007, though this varied from 6% to 39% depending on the school. Over half of our sample (56%) taught a different grade in 2007 than in 2005, though this varied by school and ranged from 24% in one school to 86% in another (see Table 2).

Data Collection: Staff Questionnaire

The school staff questionnaire included two socio-metric questions regarding the respondent's instructional advice providing and receiving behavior. Specifically, the questions ask, "To whom do you turn in this school for advice or information about mathematics instruction?" and "To whom do you turn in this school for advice or information about reading/language arts or English instruction?" Participants could write the names of up to seven colleagues in the spaces provided and were also instructed that it was not necessary to fill in all seven spaces. Other questions on the

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staff questionnaire measured various aspects of the school organization including school norms (e.g., teacher-teacher trust, collective responsibility), school leadership (e.g., the formally designated leadership positions to which they were assigned), professional development and school change (e.g., opportunity to learn, change in instructional practice), and individual characteristics (e.g., race, gender).

With respect to the validity of these items, we want to make some observations. First, while we recognize the implications of limiting respondents to naming seven advisors, we believe that this limitation does not undermine the validity of our results because only 4 of the 1,210 respondents (.3%) in mathematics networks and only 5 respondents (.4%) in ELA networks in 2005 listed seven advisors. In 2007, only 6 of the 1,194 respondents (.5%) in mathematics and only 5 respondents (.4%) in ELA filled out seven advisors. Second, two pilot studies on versions of these social network items suggests that overall, these items generate valid accounts of advice and information interactions among elementary school teachers (Pitts & Spillane, 2009). Analysis of data from one of these studies, for example, involving a "think-aloud" design, indicated that teachers interpreted the question, "To whom have you turned for advice or information about teaching (subject X)" as intended by the researchers, describing interactions that were focused on instruction and explicitly distinguishing them from other interactions that were not focused on teaching. Further, as interviewees described the kinds of advice they received from the people they listed, they tied their descriptions back to the particular subject they had been asked about.

Informed by our review of the literature and our four working hypotheses, we considered six dimensions to explore those factors that might be associated with an information or advice tie between two staff members in ELA and mathematics. Individual characteristics of staff members included in our model were race, gender, and career stage (Monge & Contractor, 2003). With respect to the formal organization, we included grade-level assignment and formally designated leadership position. In addition, we included respondents' participation in formal professional development, which we suspect is a function of both organizational and individual characteristics.

Measures

Our dependent variable is the existence of an advice or information tie between two staff members about either mathematics or English language arts in the 2006–2007 school year. For every pair of school staff i and j, if i turned to j for advice about instruction, the $i \rightarrow j$ relationship was assigned a value of 1 and 0 otherwise. We included individual-level (Level 2) and dyadic-level (every pair of school staff, Level 1) measures as cross-classified

multilevel models. Specifically, individual-level measures refer to characteristics of the individual staff members (e.g., a formal leader), whereas dyadic-level measures focus on similarities and differences between any two staff members (e.g., same grade taught).

Individual-level measures (Level 2). First, we controlled for teachers who were new in 2006 or 2007. Second, for individual-level measures, we used four variables: career stage, multiple grades taught in 2007, formally designated leadership position in 2007, and professional development in 2007 in ELA and mathematics. While career stage centers on the individual level, multiple grades taught and formally designated leadership position focuses on two aspects of the formal organizational structure. Individual or/and organizational characteristics can be measured and analyzed at either the individual level (Level 2) or dyadic level (Level 1) when building p_2 models. We operationalized these measures as follows:

- *New teachers after 2005*: Teachers were asked to indicate how many years they have taught at their schools. Teachers who responded with less than 2 years were recoded as new teachers.
- *Career stage*: We recoded responses to the question, "How many years have you worked as a teacher?" using six categories derived from work on career stage (1 = 0–3 years, 2 = 4–6 years, 3 = 7–11 years, 4 = 12–20 years, 5 = 21–30 years, and 6 = more than 30 years).
- *Multiple grades taught in 2007*: Teachers were asked to indicate what grade levels they taught at their schools. Teachers who reported teaching more than one grade level in 2007 were recoded as multiple-grade teachers.
- *Formally designated leaders in 2007*: We coded responses to the survey question "Are you formally assigned to perform a leadership role at this school as assistant principal, reform program coach/facilitator, subject area coordinator or chair, master/mentor teacher, or program coordinator (for example Title 1 coordinator)?," assigning staff who responded yes as formally designated leaders in 2007. Please note that some of these respondents also had teaching responsibilities.
- *Professional development in 2007*: The survey asked respondents to indicate how many professional development sessions they participated in this year focused on mathematics teaching and reading/language arts or English teaching (separately). The variable was scaled from 0 to 3 for each school subject (0 = none, 1 = 1–2 sessions, 2 = 3–7 sessions, and 3 = 8+ sessions).

Dyadic-level measures (Level 1). First, we controlled for the existence of a prior tie between two staff members in 2007 based on the 2005 network data. Second, to estimate the effects of dyadic-level covariates, we used four variables: race, gender, grade level taught in 2007, and difference in professional development for mathematics or ELA in 2007. While two of these variables (i.e., race and gender) focus on individual characteristics, a third variable (i.e., grade level assignment) taps into the formal organizational structure. We operationalized these four measures as follows:

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- *Previous network in 2005*: Previous network referred to the existence of a tie or connection between two staff members about either mathematics or language arts in 2005. For every pair of school staff i and j, if i turned to j for advice about instruction in 2005, the $i \rightarrow j$ relationship was assigned a value of 1 and 0 otherwise.
- *Same race dyadic covariates*: This dyadic measure takes a value of 0 if two teachers were different races, 1 if they were the same race.
- *Same gender dyadic covariates*: This measure indicator takes a value of 0 if two teachers were different genders, 1 if they were the same gender.
- *Same grade taught in 2007 dyadic covariates*: This dyadic measure takes a value of 0 if two teachers did not teach the same grade, 1 if they taught the same grade. For example, if a teacher A teaches second grade, and a teacher B teaches second and third grades, then teachers A and B teach the same grade level. If teacher A teaches a single or multiple grade levels and teacher B teaches a single or multiple grade levels, and there is overlap in the grade levels they teach, then these two teachers teach the same grade level.
- *Difference in professional development for mathematics or ELA in 2007*: This dyadic indicator uses a value of the difference between two staff members on their reported professional development for either mathematics or English language arts in 2007.[4]

Data Analysis

Individual-level factors refer to characteristics of the individual staff members (e.g., career stage), whereas dyadic-level factors focus on similarities and differences between any two staff members (e.g., same gender or race). Observed dyadic interaction, then, is seen as a function of both individual-level and dyadic-level factors.

P_2 model Network selection models attempt to explain the pattern of ties among a group of individuals. Ordinary logistic regression is not appropriate here because social network data do not satisfy the assumption of independent observations because the tie from teacher A to teacher B is not independent of a tie from teacher B to teacher A (Van Duijn & Vermunt, 2006). P_2 models take into account the nonindependence of social network observations (Van Duijn et al., 2004). The p_2 model can be thought of as a logistic regression model for the presence or absence of ties among any two actors in a network (Veenstra et al., 2007) and has been used to examine support networks of Dutch high school students (Zijlstra et al., 2006) and the effect of ethnicity on friendship among high school students (Baerveldt, Van Duijn, Vermeij, & Van Hemert, 2004; Baerveldt, Zijlstra, de Wolf, Van Rossem, & Van Duijn, 2007).[5]

The p_2 model expresses the pattern of observed ties as a function of dyadic-level characteristics as Level 1 and individual-level characteristics (each member of the dyad) as Level 2. As such, dyads are nested within provider and receiver, creating a cross-nested multilevel model. At Level 1 are

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dyads, and at Level 2 these pairs are cross-nested within providers and receivers (Crosnoe, Frank, & Mueller, 2008; Frank et al., 2004; Frank & Zhao, 2005). In our p_2 models, *advice or information$_{ij}$* was used as the dependent variable, indicating whether teacher i reported receiving advice or information from teacher j. Then *advice or information$_{ij}$* is modeled as a function of the tendency for teacher j to provide advice or information (α_j) and the tendency for i to receive advice or information (β_i). The model at Level 1, for the pair of teachers i and j, is:

Level 1 (pair-dyadic-level):

$$\log\left(\frac{p[Advice\ or\ information_{ij}=1]}{1-p[Advice\ or\ information_{ij}=1]}\right)=\alpha_j+\beta_i.$$

To identify dyadic-level characteristics, dummy variables[6] were included, indicating whether teachers had a tie in 2005, were the same race or the same gender, and whether they taught the same grade. In addition, the difference between two staff members' levels of professional development in either mathematics or language arts in 2007 was included. We also included reciprocity to control for the extent to which teacher j provided advice or information to teacher i.[7]

The level 1 model is:

$$\log\left(\frac{p[Advice\ or\ information_{ij}=1]}{1-p[Advice\ or\ information_{ij}=1]}\right)=\alpha_j+\beta_i+\delta_1(\text{prior relationship})_{ij}$$

$$+\delta_2(\text{same race})_{ij}+\delta_3(\text{same gender})_{ij}$$

$$+\delta_4(\text{same grade taught})_{ij}+\delta_5(\text{difference in professional development})_{ij}$$

$$+\delta_6(\text{reciprocity : advice}_{ji}).$$

Generally, the positive effect of individual-level or dyadic-level characteristics indicates that the characteristic increases the probability of a tie (Baerveldt et al., 2004; Lazega & Van Duijn, 1997; Moolenaar, 2010; Van Duijn et al., 2004; Veenstra et al., 2007).[8] Specifically, the larger the value of δ_1, the more we would infer that the current ties in advice and information sharing are affected by previous ties. The larger the value of δ_2 and δ_3, the more we would infer that the patterns of advice or information sharing are affected by the dyadic-level characteristics as defined by same race or same gender. The term δ_4 quantifies how the formal organization as represented by grade level shapes advice or information ties, and the term δ_5 quantifies how the difference in professional development shapes advice or information ties. Finally, the term δ_6 indicates the extent to which teachers mutually exchange advice and information.

We modeled the tendencies of teachers to be chosen as providing and receiving advice or information at a separate level:

Level 2a (*j*: provider of advice or information)

$$\alpha_j = \gamma_0^{(\alpha)} + u_{0j}.$$

Level 2b (*i*: receiver of advice or information)

$$\beta_i = \gamma_0^{(\beta)} + v_{0i}.$$

Here, the random effects u_{0j} and v_{0i} are assumed to be normally distributed and account for dependencies associated with tendencies to provide or receive advice or information that affect all relations in which a given individual engages. To estimate what individual-level attributes of the provider and receiver of advice or information predict a tie, new teachers, multiple-grade teachers, and formally designated leaders were included in provider effects in Level 2a, and career stage and professional development were included in receiver effects in Level 2b.[9]

The Level 2 model is:

Level 2a (*j*: provider effect)

$$\alpha_j = \gamma_0^{(\alpha)} + \gamma_1^{(\alpha)} \text{new teachers}_j + \gamma_2^{(\alpha)} \text{multiple} - \text{grade teachers}_j$$
$$+ \gamma_3^{(\alpha)} \text{formally designated leaders}_j + u_{0j}.$$

Level 2b (*i*: receiver effect)

$$\beta_i = \gamma_0^{(\beta)} + \gamma_1^{(\beta)} \text{career stage}_i + \gamma_2^{(\beta)} \text{professional development}_i + v_{0i}.$$

Additionally, a random density effect (omega) across 30 schools was included in the multilevel p_2 model, which indicates whether or not there was variation in the intercepts (γ_0) across 30 schools.[10] To aid interpretation of statistical significance, quantiles from the distributions of estimation samples are reported alongside each parameter estimate in the results tables. The quantiles between 2.5 and 97.5 define the Bayesian analogue to a frequentist confidence interval. Therefore, if the quantiles between 2.5 and 97.5 do not include "zero," the estimate will be statistically significant at the 5% level.

Limitations

Our analysis has several limitations. First, the patterns of ties we identify may be a function of some unobservable or unmeasured variables. Although we control for prior ties, our analysis relies chiefly on a cross-sectional analysis and thus has limitations with respect to identifying causal relations. Second, although we measured professional development in ways particular to the two core elementary school subjects, we do not know whether professional development was required by the school or school district or is mostly a function of teachers' personal preferences. Further, our measure

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of professional development is based on number of sessions attended, though we have no way of determining the duration of a session. Third, an exclusive focus on dyadic interactions has limitations because factors beyond the dyad can affect dyadic interactions. Consider three elementary teachers *A, B*, and *C*. While a dyadic-focused analysis can provide insight into the factors associated with the patterns of interactions among any pair of these three teachers, it fails to take into account that relationships between any pair is may be affected by their connections to the third teacher (Snijders, Pattison, Robins, & Handcock, 2006). Still, some recent research suggests most of the structure of triads can be explained by lower-order properties—individual and dyadic (Faust, 2007).

Our analysis is also limited with respect to the generalizability of our findings about tie formation because we rely on data from 30 elementary schools in a single midsized urban school district. Thus, making claims about elementary schools in general in the state in which Cloverville is located or elementary schools in the United States is beyond the scope of our analysis. At the same time, considering that our analysis is in the theory-building, hypotheses-generating tradition rather than hypotheses testing, our sample is appropriate in that we include all 30 schools from a single school district. By including all schools, rather than a subsample, we maximize the variation in our sample on conditions that might account for tie formation while at the same time holding constant the school district policy context that might also influence ties. Maximizing variation is critical in theory-building, hypotheses-generating work. Still, we acknowledge that future work will undoubtedly offer more empirical insights on the critical issue of tie formation in schools. For example, some prior work shows a relationship between the type of curricula used in schools and teachers' social networks (Stein & Coburn, 2008). Due to the lack of variance between schools in our study on curricula we were unable to examine relations among school curricula and network ties.

Results: Modeling Instructional Ties in Schools

We report on findings from our multilevel p_2 models, identifying those factors that are associated with the occurrence of a tie between any two staff members across the 30 schools in our sample. The models presented in Table 3 show the likelihood of advice and information ties between two colleagues as a function of individual-level measures (provider and receiver) and dyadic-level measures determined by provider-receiver similarities based on data from our 30 schools.[11] Provider or receiver effects of individual-level measures refer to attributes of the provider or receiver of advice or information that account for the observed patterns in teachers' networks. Dyadic effects refer to the extent that two teachers *with mutual attributes* have a tie in advice and information providing and receiving.

Table 3
Multilevel p₂ Models for 30 Elementary Schools

English Language Arts (ELA) Network	e^{estimate}	Parameter		Quantiles	
		Estimate	SE	2.5	97.5
Provider variance		2.23	0.24	1.80	2.74
Receiver variance		1.63	0.19	1.26	2.02
Provider-receiver covariance		-0.29	0.16	-0.63	0.02
Density		-6.76	0.65	-7.83	-5.59
Reciprocity		1.70	0.20	1.32	2.07
Omega for multilevel model		3.59	2.51	0.43	9.25
Individual level (Level 2)					
Provider level (Level 2a)					
New teachers	0.46	-0.78	0.20	-1.22	-0.45
Multiple-grade teachers	0.12	-2.15	0.17	-2.46	-1.82
Formally designated leaders	2.89	1.06	0.15	0.77	1.32
Receiver level (Level 2b)					
Career stage	0.79	-0.24	0.04	-0.32	-0.15
Professional development in ELA	2.05	0.72	0.10	0.53	0.91
Dyadic level (Level 1)					
Previous ELA tie	15.64	2.75	0.17	2.42	3.11
Same race	1.79	0.58	0.10	0.38	0.78
Same gender	1.36	0.31	0.17	-0.03	0.64
Same grade taught	24.53	3.20	0.13	2.92	3.43
Difference in professional development in ELA	0.73	-0.32	0.08	-0.46	-0.17
Deviance		4,286			
Bayesian information criterion (BIC)		36,614			
Newton-Raftery p4		-2,152	34		
Log-likelihood		-2,547		-2,617	-2,483

Table 3 (continued)

Mathematics Network	e^{estimate}	Parameter Estimate	SE	Quantiles 2.5	97.5
Provider variance		1.76	0.22	1.40	2.24
Receiver variance		1.98	0.27	1.56	2.55
Provider-receiver covariance		−0.25	0.14	−0.53	0.02
Density		−7.24	0.62	−8.37	−6.13
Reciprocity		1.90	0.21	1.48	2.27
Omega for multilevel model		3.36	2.74	0.20	9.72
Individual level (Level 2)					
Provider level (Level 2a)					
New teachers	0.44	−0.83	0.20	−1.26	−0.51
Multiple-grade teachers	0.16	−1.85	0.17	−2.16	−1.48
Formally designated leaders	3.60	1.28	0.16	1.00	1.60
Receiver level (Level 2b)					
Career stage	0.78	−0.25	0.05	−0.36	−0.15
Professional development in mathematics	2.41	0.88	0.11	0.63	1.09
Dyadic level (Level 1)					
Previous mathematics tie	9.03	2.20	0.18	1.86	2.56
Same race	1.57	0.45	0.11	0.24	0.66
Same gender	1.51	0.41	0.18	0.04	0.77
Same grade taught	20.49	3.02	0.13	2.77	3.29
Difference in professional development in math	0.70	−0.35	0.08	−0.50	−0.18
Deviance		4.048			
BIC		36.376			
Newton-Raftery p4		−2.033			
Log-likelihood		−2.403	35	−2.471	−2.335

Note. Sample size was 1,142 after excluding missing values in career stage, professional development in mathematics or ELA, and new teachers.

We conducted separate analysis for mathematics and language arts because prior work suggests that how elementary teachers think about their work and how they organize for instruction depends on the school subject (Spillane, 2000, 2005; Stodolsky, 1988). As the results are similar for both school subjects, we only discuss our findings for ELA in the following. For readers interested in the mathematics results, these are included in Table 3. We organize our findings around the hypotheses specified in our framing section.

Individual Considerations (Hypothesis 1a and Hypothesis 1b)

Our first two hypotheses focus on individual characteristics. Specifically, we hypothesized that race, gender, and years of experience of organizational members would predict their ties with one another.

Similarity of race and gender as individual characteristics were associated with having an advice or information tie among staff. Staff members of the same race were more likely to provide or/and receive advice or information from one another than those of different races, as suggested by a positive dyadic effect of same race (.58) (see Table 3). Similarly, staff members were more likely to provide or/and receive advice or information from a colleague of the same gender, as suggested by a positive dyadic effect of same gender (.31). These small positive values (.58 and .31) indicate that having the same individual characteristics raises the odds of having a current tie by 79% for race and 36% for gender and offers support for our first hypothesis.[12] More experienced teachers were less likely to receive advice or information about ELA, as indicated by a negative receiver effect of career stage (−.24).

Organizational Considerations (Hypothesis 2, Hypothesis 3a, and Hypothesis 3b)

Recognizing that social ties are embedded in organizations, we also examined how particular aspects of the formal organizational structure enabled and constrained interactions among organizational members. We hypothesized that holding a formally designated leadership position, having a teaching assignment that spanned grades, and teaching in the same grade level would enable and constrain interactions among staff about instruction.

Offering support for our second hypothesis, school staff members with formally designated leadership positions were more likely to provide advice or information than those who did not have such designations as reflected in a positive provider effect of formally designated leaders (1.06). Further, teachers teaching multiple grade levels were less likely to provide advice or information compared with teachers who did not teach across grade levels as reflected in a negative provider effect of multiple-grade teacher (−2.15) and providing support for our third hypotheses. A positive dyadic effect of same grade taught (3.20) indicates that providing or/and receiving advice

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or information about ELA is more likely for teachers teaching in the same grade level. This offers support for our third hypothesis, suggesting how an aspect of the formal organizational structure—grade level assignment—mattered with respect to ELA advice or information providing and receiving at the dyadic level.

Professional Development (Hypothesis 4a and Hypothesis 4b)

As discussed previously, we see advice and information ties as critical for knowledge development. Recognizing that formal professional development is a potential source of advice and information, we hypothesized that teachers' participation in professional development would be related to their social interactions with one another.

A negative dyadic effect of difference in professional development (−.32) suggests that the more professional development the provider has relative to the receiver, the more likely advice and information are provided. This supports our fourth hypothesis that information and advice in schools may flow from those with more advice and information to those with less, assuming that those with more professional development in a particular subject have more advice and information about that subject. A positive receiver effect of professional development (.72) indicates that teachers who report more professional development in ELA were more likely to receive advice and information about ELA from colleagues. It is important to remember here that it is professional development specific to ELA, rather than just professional development in general, that is associated with more advice and information flow.

Gauging the Effects of Formal Organizational Structure on Social Ties

In addition to the findings from our p_2 models, we also constructed probability tables for both ELA and mathematics in order to gauge the effect of the formal organizational structure at the dyadic level and individual level on the probabilities of the four different dyad outcomes. These probabilities give us a more concrete sense of what various combinations of the variables (e.g., being in the same grade but of different race) might mean for the "average" Cloverville teacher's advice and information interactions. As the expected dyad probabilities of mathematics advice and information ties were similar to those for ELA, we only report on the probability tables for ELA advice and information providing and receiving (Tables 4 and 5).

Each of the two-by-two cell blocks in Tables 4 and 5 show the probabilities of each possible dyad outcome (00, 01, 10, 11) for pairings of staff. While 00 indicates that no tie existed, 11 indicates a reciprocated tie, and both 01 and 10 indicate a tie where one person in the dyad received advice from the other but the exchange was not reciprocated. Ignoring random effects, we infer the effect of the variables on the probabilities of the different dyad outcomes from our p_2 model. In other words, these are the expected

Table 4

Expected Dyad Probabilities of English Language Arts (ELA) Advice Relationships of Dyadic-Level Characteristics (Similarity of Gender, Race, and Grade Level Taught)

(0,0) (0,1)
(1,0) (1,1)

	Same Grade			
	Race			
	Same		Different	
Gender				
Same	**.02**	.13	**.06**	.13
	.13	.72	.13	.68
Different	**.04**	.13	**.11**	.12
	.13	.70	.12	.65

	Different Grade			
	Race			
	Same		Different	
Gender				
Same	**.93**	.01	**.98**	.00
	.01	.05	.00	.02
Different	**.96**	.01	**.99**	.00
	.01	.03	.00	.01

Note. For teachers who are not new in 2006 or 2007 and have the same career stage in 2007 with no professional development in 2007. In addition, these teachers do not teach multiple grade levels in 2007 and are not formally designated leaders in 2007. Finally, these teachers had no ELA tie in 2005. (0,0) means neither receiving nor providing advice and information. (0,1) means providing advice and information. (1,0) means receiving advice and information. (1,1) means both receiving and providing advice and information. Bold used only on **(0,0)** in the two-by-two matrix.

probabilities for an average teacher with the characteristics tested in the model.

Similarity of grade level taught. The following analyses and results will show that similarity of grade level taught is important in tie formation. As we documented previously, we found a statistically significant association between grade-level assignment and ELA ties. Using Table 4, we can gauge how same-grade assignment (an aspect of the formal organization) might be related to ELA advice or information providing and receiving behavior at the

dyadic level for Cloverville teachers with the characteristics in our model. Table 4 captures the expected dyad probability of a tie between two teachers who are not new in 2006 or 2007, did not have an ELA tie in 2005, are at the same career stage in 2007, report no ELA professional development in 2007, do not teach multiple grade levels in 2007, and are not formally designated leaders in 2007.

To help with interpretation of Table 4, let us focus on the first cell and read the data clockwise starting in the top righthand corner. First, the expected dyad probability of a tie between two teachers of the same race and gender, teaching in the same grade is .02 at (0,0) meaning that the likelihood of these two teachers *neither* receiving *nor* providing advice and information to one another is only 2%. In other words, two teachers of the same race and gender, who did not have an ELA tie in 2005, but now teach in the same grade are very likely (98%) to have an ELA tie. Second, moving clockwise (0,1), the .13 means that the likelihood of teacher A providing advice and information to teacher B (both of same race and gender and teaching in the same grade) is 13%. Third, and continuing to move clockwise (1,1), .72 means that the likelihood of both receiving and providing advice and information between A and B is 72%. Fourth, the .13 (1,0), means that the probability of teacher A receiving advice and information from teacher B is 13%. To summarize, if two teachers *without* a formally designated leadership position in 2007 and ELA professional development in 2007, had no ELA tie 2005, do not teach multiple grade levels in 2007, teach in the same grade in 2007, are not new in 2006 or 2007, and are of the same race and gender, the probability of having an ELA tie in 2007 is 98% (13% + 13% + 72%).[13] Further, the same two teachers would have a 72% chance of having a reciprocal tie about ELA.

Moving on to consider some of the other cells in the top half of Table 4, we can discern several patterns: Two teachers of the same gender but of different races, neither with a formally designated leadership position in 2007 nor ELA professional development in 2007, not having had an ELA tie in 2005, not teaching multiple grade levels in 2007, teaching in the same grade in 2007, and not being new in 2006 or 2007 have a 94% (13% + 13% + 68%) chance of having a tie in 2007. Even if two teachers without formally designated leadership positions were of different races and different genders but taught in the same grade, the probability of having a tie in 2007 was 89% (12% + 12% + 65%). Overall, this analysis suggests that there are small estimated effects of race and gender on ELA ties when two teachers without a formally designated leadership position in 2007 and ELA professional development in 2007, have no ELA tie in 2005, do not teach multiple grade levels in 2007, teach in the same grade in 2007, and are not new in 2006 or 2007. In sum, grade-level assignment is strongly associated with having an ELA tie.

The situation changes, however, when we remove the constraint of grade-level assignment, a key aspect of the formal school organization. Examining the lower half of Table 4 we get a sense of the importance of grade-level assignment to ELA ties. Specifically, the estimated effects of race and gender homophily at the dyadic level become more pronounced when we consider the existence of a tie between teachers in *different* grades. Most striking, if teacher A and B without a formally designated leadership position in 2007 and ELA professional development in 2007 were teaching different grades in 2007, have no ELA tie in 2005, do not teach multiple grade levels in 2007, and are not new in 2006 or 2007, regardless of race and gender, the probability of having a tie in 2007 is less than 8%. Thus, in the absence of an ELA tie in 2005, not having a formally designated leadership position, not attending ELA professional development in 2007, not teaching multiple grade levels in 2007, not being new in 2006 or 2007, and teaching the same grade in 2007 is critical in the formation of an ELA tie in 2007. This suggests that the formal organization in terms of grade-level assignment trumps race and gender homophily because tie formation is much more associated with grade level taught. Thus, changing grade-level assignment can generate new ELA ties among teachers regardless of race and gender.

Professional development. As we discussed previously, our analysis found a statistically significant association between amount of professional development and ELA ties at both the dyadic level and the receiver level. So, we calculated the expected dyad probabilities of ELA ties with respect to amount of ELA professional development for teachers of the same race and same gender with no ties in 2005 and teaching different grades in 2007 (see Table 5).[14] The expected probabilities shown in Table 5 were calculated to estimate the effect of difference in ELA professional development at the dyadic level and to estimate the effect of professional development (PD) at receiver level. To begin, the first cell in Table 5 shows that the likelihood of A and B *neither* receiving nor providing advice and information to/from one another is 63% – 0.63 at (0,0). In other words, the estimated effects of teacher A and B with the same high amounts of ELA PD (same race and gender, no ties in 2005, teaching different grades) having an ELA tie in 2007 is 37%.

Reading across the cells in the first row in Table 5 we see the estimated effects of changes in amount of ELA PD *at the provider level* on ELA ties while holding PD at the receiver level constant (i.e., 8+ PD of receiver level). Specifically, decreases in the provider's amount of ELA professional development (i.e., from 8+ PD to 3–7 PD and so on) decreases the chances of two teachers having an ELA tie in 2007 from 37% to 8%.[15] In other words, with increases in the providers' amount of ELA professional development, the chances of a tie between teacher A and B increases from 8% to 14% to 24% to 37%.

A rather different picture emerges, however, when we focus on the receiver's amount of professional development. Reading down the first column in Table 5, which holds the provider's amount of ELA professional

Table 5

Expected Dyad Probabilities of English Language Arts (ELA) Tie of Professional Development (PD) in ELA Both at Dyadic and Individual Levels

(0,0) (0,1)
(1,0) (1,1)

PD		PD of Provider Level (Level 2a:j)							
		8+ PD		3–7 PD		1–2 PD		No PD	
PD of receiver level (Level 2b:i)	8+ PD	**.63**	.01	**.76**	.00	**.86**	.00	**.92**	.00
		.06	.30	.04	.20	.02	.12	.01	.07
	3–7 PD	**.64**	.01	**.77**	.01	**.86**	.00	**.92**	.00
		.05	.30	.03	.19	.02	.12	.01	.07
	1–2 PD	**.65**	.02	**.78**	.02	**.87**	.01	**.93**	.01
		.05	.08	.03	.17	.02	.10	.01	.05
	No PD	**.65**	.05	**.78**	.03	**.87**	.02	**.93**	.01
		.05	.25	.03	.16	.02	.09	.01	.05

Note. For teachers who are not new in 2006 or 2007 and have the same career stage in 2007, same race, same gender, and no formal leadership position in 2007. In addition, these teachers had no ELA tie in 2005 and taught different grade levels in 2007. (0,0) means neither receiving nor providing advice and information. (0,1) means providing advice and information. (1,0) means receiving advice and information. (1,1) means both receiving and providing advice and information. Bold used only on **(0,0)** in the two-by-two matrix.

development constant (i.e., 8+ PD of provider level), we can estimate the effects of the receiver's amount of ELA PD on an ELA tie in 2007. Specifically, holding the provider's amount of ELA professional development constant, increases in the receiver's amount of ELA professional development improves the likelihood of these two individuals forming an ELA tie in 2007 by 2% at most. An increase in the receiver's amount of ELA professional development from none to eight-plus sessions only improves the chances of a tie in 2007 between teacher A and B from 35% to 37%.

To summarize, increases in the provider's amount of ELA professional development in 2007 improves the chances of two teachers having an ELA tie in 2007 by as much as 29%, whereas similar increases in the receiver's amount of ELA professional development in 2007 improves the likelihood of a tie in 2007 between two teachers by only 2%. When we consider ELA professional development in 2007 at the individual and dyadic levels in the models, therefore, the chance of forming an ELA tie in 2007 is more strongly associated with the provider's amount of ELA professional development in 2007 rather than the receiver's amount of ELA professional development in 2007.

Discussion and Conclusion

Scholarship in education over several decades has documented the role of social capital in enabling school improvement, showing how social relations can be a source of various resources such as trust and expertise. As social capital theorists point out, however, the existence of a social tie, a necessary if insufficient condition for social capital development, is neither a "natural" nor "social" given (Bourdieu, 1986, p. 249). Yet, there is a scarcity of empirical knowledge on those factors associated with tie formation in schools. In this article, we explored some of those factors by focusing on advice and information ties, social resources accessed through ties and critical for developing new knowledge. Our analysis suggests that while school leaders' and teachers' individual characteristics (e.g., race and gender) are associated with the existence of instructional advice or information ties, the formal organization in the form of grade-level assignment, having a formally designated leadership position, and teaching a single grade trumps individual characteristics. Our analysis suggests that "formalities" can influence practice (Stinchcombe, 2001), showing how aspects of the school's formal organizational structure are associated with instructional advice and information providing and receiving behavior or practice in schools. And, considering that social ties are a necessary (if insufficient condition) for social capital formation, our work shows how formalities might be important in social capital development in schools. This finding is consistent with recent work in sociology that shows how social capital development is influenced by organizational arrangements not just individual preferences (Small, 2009).

More concretely, controlling for prior ties our analysis shows that grade-level assignment is strongly associated with tie formation. And, grade level matters in tie formation regardless of school subject. While prior work suggests that elementary school teachers' instructional advice providing and receiving patterns may differ by school subject (Hayton & Spillane, 2008; Spillane, 2006), our analysis suggests that formal structure is significantly and strongly associated with social ties among teachers in both language arts and mathematics. There are several possible explanations for our finding about relations between grade level and advice and information seeking behavior. In elementary schools, teachers teaching similar grades are typically located adjacent to one another, so physical proximity may increase the probability of forming a tie. But, physical proximity may be only part of the story. The significance of teaching the same grade may also reflect other aspects of the formal organizational structure such as participation in the same organizational routines (Spillane & Coldren, 2011; Spillane et al., 2011). Teachers in the same grade, for example, are more likely to participate in more of the same organizational routines (e.g., grade-level meetings), creating more occasions for teachers in similar grades to interact with one another and shared advice and information than teachers in different grades

(Frank & Zhao, 2005; Penuel et al., 2010). In addition, teachers in the same grade typically teach the same curricular content using the same curricular materials. These arrangements not only provide incentives to seek out advice and information from one another (e.g., relatively similar instructional goals and challenges), but also provide common artifacts around which teachers can interact (e.g., identical standards, similar student achievement data, same textbooks and curricula).

Our current analysis is unable to pinpoint which combination of mechanisms might be at play in accounting for the significant and strong estimated effect of grade-level assignment on advice or information providing and receiving behavior. Future research could make progress on these issues in several ways. First, while teachers of the same grade are typically located in adjacent classrooms, spatial proximity is about more than simply being next door to a colleague. Specifically, work in other fields suggests that "people" flow within buildings, rather than simply being next door, is important in tie formation (McPherson et al., 2001, pp. 429–430). Thus, work that systematically examines the flow of staff within buildings (e.g., high traffic routes such as to the principal's office or to the main entrance) may be able to tease apart physical proximity from other aspects of being in the same grade (e.g., participating in the same formal organizational routines, teaching the same curricula). Second, research might capitalize on natural variation in an aspect of the formal organizational such as formal organizational routines and compare over time tie formation in schools that have mostly grade-level specific routines (e.g., grade-level meetings) with tie formation in schools that have formal organizational routines that cut across grades. Similarly, scholars might capitalize on changes in formally designated leadership positions in schools (e.g., introduction of mathematics coaches) to examine how this aspect of the formal organizational structure affects tie formation. Third, field experiments can help generate empirical knowledge about tie formation and indeed whether and how we can intervene directly to shape social capital development in schools. For example, using randomized control trials to study interventions that involve the implementation of different types of organizational routines (e.g., within grade vs. between grade, school subject specific vs. school subject neutral) would generate knowledge about the efficacy of different types of interventions designed to develop social capital.

As we noted earlier, social ties are a necessary but not sufficient condition for social capital development. Thus, another area for future research involves differentiating between advice and information ties that do and don't contribute to knowledge development (and potentially changes in instructional practice) over time. Using longitudinal social network data over several years, we could explore not only those factors associated with the formation of advice and information ties at say time two and in turn the effect of these new ties on instructional knowledge (and/or

practice) at time three. SIENA (Simulation Investigation for Empirical Network Analysis) estimation procedure would be valuable here, allowing us to simultaneously examine tie formation and influence through the network (Kim, 2011; Steglich, Snijders, & Pearson, 2010; Steglich, Snijders, & West, 2006). Such a research design would enable us to differentiate between ties and do and do not contribute to social capital and knowledge development.

Another area for future research concerns the role of formally designated school leaders in social capital development. Our analysis suggests that those individuals with formally designated school leadership positions were more likely to provide instructional advice and information than classroom teachers with no such designations. Still, formally designated leadership positions in the 30 schools ranged from full-time school principals and assistant principals to part-time mentor teachers, coaches, ELA coordinators, and so on. Some recent work suggests that formally designated school leaders are positioned differently in their school's instructional advice and information networks depending on their particular formal position (Spillane & Kim, in press). Thus, examining more closely whether and how the particular formal leadership position is associated with providing instructional advice and information is another potentially fruitful line of inquiry for research on social capital development.

While more research is needed, our work does offer some direction for local policymakers and school administrators concerned with developing social capital. To begin with, considering that formally designated school leaders are more likely to provide advice and information, school and district administrators should take seriously the selection of individuals for these positions. With respect to grade-level assignment and tie formation, regardless of the particular mechanism or combination of mechanisms (e.g., physical proximity, participating in the same organizational routines, teaching the same curricular material) that might be at play, our analysis suggests that grade-level assignment affects instructional advice and information providing and receiving practice among staff. Without deliberate intervention over time, however, grade-level assignment will generate social capital that will be distributed in clumps, rather than through uniform or even flows across the school. As a result, teachers of one grade level may not be able to access the knowledge possessed by those in other grades. Such segmented social capital can inhibit learning because learning and the knowledge necessary for successful teaching are not neatly compartmentalized in grades. A third-grade teacher may have knowledge for teaching reading that has great value for her second- or fourth-grade colleagues. Further, advice and information ties that span grades are critical for the vertical alignment of the school curriculum enabling, for example, second-grade teachers to understand what content to cover in order to prepare students for third grade or helping the third-grade teacher figure out what materials her new class gained mastery of in second grade.

The question, then, turns to the factors that school administrators can intervene on to generate between-grade social ties. First, by reassigning teachers to different grades, school leaders can enable the formation of new advice and information ties among school staff. Moreover, considering that ties from prior years are strongly associated with current ties, reassigning teachers to new grades also promotes cross-grade interactions. An issue for school leaders here concerns how to assign teachers to grades. If, as our analysis suggests, grade-level assignment is associated with advice and infor-mation providing and receiving behavior among school staff, then it seems that school leaders would be well advised to think carefully about how they distribute teachers across grade levels. Specifically, school leaders might ensure that ''master'' or ''exemplary'' teachers are dispersed across grades to maximize their potential influence on their colleagues. In this way, school leaders would increase all teachers' access to the knowledge and expertise of these master teachers.[16] Second, school administrators also might deliber-ately cultivate cross–grade-level ties by designing and implementing organi-zational routines that involve teachers from two or more grades cross-school committees. Finally, considering that formally designated school leaders are more likely to provide advice and information school and district administra-tors should take seriously the selection of individuals for these positions and think about how these individuals might build ties across grades.

Our account also suggests that school leaders might also strategically use professional development to promote social capital development. Of partic-ular note here is the dyadic-level effect of difference in professional devel-opment suggesting that the more professional development the provider has relative to the receiver, the more likely advice and information are pro-vided. This suggests that the returns from professional development may not simply be direct returns in improving the information and skill of those who attend but may also indirectly contribute to other staff members on the job learning through the advice and information provided by those who attend more professional development. Indeed, increases in a provider's amounts of professional development were associated with substantial increases in the likelihood of a tie. At the same time, our analysis found that teachers who had more professional development were more likely to receive advice and information from colleagues. There are several possible interpretations of the professional development findings. Teachers with more professional development may be encouraged by school leaders to relay the advice and information they gained through professional development back to their colleagues. Another scenario is that teachers who are experiencing more instructional difficulty may seek out, or be pressured to attend by school leaders, more professional development and at the same time receive more advice and information from colleagues who want to help them to improve their practice. Here again there are several questions for future research. Why is it that teachers who receive more professional development

are more likely to receive advice and information from colleagues? Why is it that the more professional development the provider has relative to the receiver the more likely advice and information is provided?

In this article, we showed how gender, race, and career stage as well as aspects of the formal organization are associated with the existence of social ties, a necessary if insufficient condition for social capital development in schools. In particular, our analysis points to the importance of aspects of the school's formal organizational structure—grade-level assignment, teaching a single grade, and formal leadership position—in advice and information ties among pairs of school staff members, while controlling for the existence of a tie from a prior year. Our account suggests that school leaders can influence ties among staff, creating conditions necessary for social capital development, through their decisions about teachers' grade-level assignments and selection of staff for formally designated leadership positions, many of whom have regular teaching duties.

Notes

[1]To express the dyadic relationship, we use "provide or/and receive" because there are three situations that are (a) only provide, (b) only receive, and (c) both provide and receive.

[2]Not included in the survey sample are art, music, and computer teachers; paraprofessionals, administrative secretaries, and clerks; social workers; psychologists; and food service workers. Notably, the principal did not complete this survey. However, this did not prevent staff members from naming their principal, or any other colleague not part of the sample, as an individual from whom they seek instructional advice.

[3]Among the 1,194 staff members, 834 (about 70%) responded to the survey in both 2005 and 2007. To address the changing composition of our sample in our analysis, we used a structural zero in network data as a method to treat missing values. The structural zero assumes that if someone was not present in the school in 2005, they did not have ties to people in that school. For the most part this is an accurate reflection of the network, even though it is a constraint imposed by organizational membership.

[4]We calculated these differences as professional development of i minus professional development of j. Thus, positive value in difference means that professional development of i is more in amount than professional development of j while negative value in difference means that professional development of i is less in amount than professional development of j. In addition, zero value in difference means that professional development of i is the same amount as professional development of j. For example, if receiver (i) of advice or information reported less attending professional development than provider (j) of advice or information, we would have negative value in difference in professional development because this is not absolute difference in professional development.

[5]The parameters of the p_2 model are not computed directly but instead are generated using a Markov Chain Monte Carlo (MCMC) estimation algorithm (see Van Duijn, Snijders, & Zijlstra, 2004; Zijlstra, Van Duijn, & Snijders, 2005, 2006). We used 4,000 as burn in and 10,000 as sample size in the MCMC estimation.

[6]In the p2 software, dummy coding (0 and 1) was used in order to capture and estimate the effect of existence of dyadic-level attributes between provider and receiver on tie formation between two teachers.

[7]We excluded new teachers, career stage, multiple-grade teachers, and formally designated leaders in Level 1 because our hypotheses for these variables focused on the individual level (Level 2).

[8]Positive dyadic effects suggested that the dyadic-level measures increase the likelihood of teacher's advice and information providing or/and receiving behavior while negative dyadic effects indicated that the dyadic-level measures decrease the chance of teacher's advice and information providing or/and receiving behavior. In addition, positive provider effects suggested that the individual-level measures increase the likelihood of teacher's advice and information providing behavior while negative provider effects indicated that the individual-level measures decrease the chance of teacher's advice and information providing behavior.

[9]We specified this final model after first exploring several other models. We excluded career stage and professional development variables in provider effect because these variables were not statistically significant at the 10% level. Similarly, we excluded new teachers, multiple-grade teachers, and formally designated leaders variables in receiver effect because these variables were not statistically significant at the 10% level. In addition, the difference between controlling for previous ties as a dyadic characteristic (Level 1) and the inclusion of the new teachers variable as an individual characteristic (Level 2) is that the dyadic variable reflects differences among those dyads present at time 1—some teachers were already helping another at Time 1 and others were not. On the other hand, the new teacher variable pertains uniformly to all dyads associated with a teacher who is new at Time 2.

[10]Including the error term at the school level accounts for school-level variance in density (making parametric assumptions) even though we do not model the variation at the school level.

[11]The positive receiver and provider variance indicated that there is still variation among teachers in the extent to which teachers provide and receive advice and information whereas the negative provider-receiver covariance indicated that teachers who provide more advice and information have a lower chance of receiving advice and information. In addition, the negative density effect indicated that advice and information are provided in less than half of all possible dyads while the positive reciprocity effect indicated that teachers are more likely to help others who help them. Finally, the positive random density effect (omega) across schools indicated that there is variation in the density across schools.

[12]We used odds to compute the following formula: $e^{0.58} - 1 = 1.79 - 1 = 0.79 = 79\%$ for same race and 36% for same gender.

[13]Total 100% probability consisted of four parts; no tie between A and B (2%), direct tie from A to B (13%), direct tie from B to A (13%), and mutual tie between A and B (72%). Because we did not consider individual-level measures in this example, the probability of two direct ties (A to B and B to A) is the same.

[14]We calculated these expected probabilities to take into account both the effect of difference in English language arts (ELA) professional development at the dyadic level and the receiver level.

[15]Seven percent (1% + 1% + 5%) when both teachers reported no professional development. In addition, 37% (1% + 6% + 30%) when both teachers reported participation in more than eight professional development sessions. Because we also considered individual-level measures at receiver level in this example, the probability of two direct ties (A to B and B to A) is not always the same.

[16]Of course other factors have to be taken into account in assigning teachers to particular grades. Some teachers, for example, may be better suited to working with early elementary students than others.

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