Social Networks and Educational Opportunity

13

Kenneth Frank, Yun-jia Lo, Kaitlin Torphy, and Jihyun Kim

Abstract

This chapter reviews the basic structures of social networks and how they have been used to study interrelationships in schools, most prominently those among teachers and students. Part of this discussion includes how network structures are visualized, with multiple examples. These graphic representations demonstrate how information flows in social organizations and is influenced by interactions with colleagues and personalized selections. One of the most important contributions of network analysis is the ability to visualize influence and how inferences of influence can be determined. Influence modeling shows how actors change behaviors in response to others. Selection models show how actors choose with whom they wish to interact and allocate their resources. Finally, this work shows how network forces can facilitate learning by creating opportunities and regulating specific practices. This is particularly beneficial for modeling interactions of teachers within schools and understanding how interactions among teachers and administrators create norms and conditions that can promote or impede reforms within schools. Teacher networks can be especially useful in the formation of learning communities and can enhance effective teaching. But networks also exist outside of school, and the final section of the chapter discusses the emergence of virtual social networks and how professionals are interacting and using them.

In this chapter we review how social networks have been studied to inform our understanding of how schools allocate opportunities for education. In particular, we focus on the role of the school as a social organization that facilitates coordinated action and allocates resources to students through informal networks and formal structures involving teachers and administrators.[1] In turn,

[1]For a complete review of social networks in educational research, see Frank (1998); on teacher networks and the implementation of innovations, see Carolan (2013), Daly (2010), Yoon and Baker-Doyle (2018) and Frank et al. (2014); on teacher networks and collaboration, see Moolenaar (2012); and on network formation see

With contribution from Kim Jansen.

K. Frank (✉) · Y.-j. Lo · K. Torphy
Michigan State University, East Lansing, MI, USA
e-mail: kenfrank@msu.edu; loyunjia@msu.edu; torphyka@msu.edu

J. Kim
Lehigh University, Bethlehem, PA, USA
e-mail: jik317@lehigh.edu

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coordination and resource flows affect the equity of educational opportunities.

Given our attention to coordination and resource flows, processes of social capital drive much of what we will explore below. As we use it here, social capital represents the potential for individuals to access resources through social relationships (Lin 2002; Portes 1998; see Carolan 2013, chapter 10).[2] In particular, this applies to how teachers access information or support from other teachers (Frank et al. 2004; Penuel et al. 2009), or how administrators use their informal relations to influence teaching (Coburn 2005; Coburn and Woulfin 2012; Daly et al. 2010, p. 375; Moolenaar and Sleegers 2015; Sun et al. 2013a; Hopkins and Spillane 2014). In fact, the social capital on which teachers draw may be more important for implementing innovations than narrowly focused human capital (Yoon et al. in press). The flows of such resources can improve teachers' capacity to teach, innovate, and coordinate with one another. Correspondingly, such flows of resources conveyed by informal networks are critical to how schools as social organizations distribute educational opportunity.

In the next section, we begin with a general introduction to social network analysis in terms of the structure and function of networks. This includes graphical visualizations of networks as well as the fundamental models of how actors influence one another through networks and how they select with whom to form network ties. While the models have many applications, the typical drivers of influence and selection can accentuate existing differences among teachers as teachers tend to interact with similar others (e.g., of the same grade) and are influenced by those with whom they interact. In turn, these differences among teachers generate differential learning opportunities that can lead to stratification.

We then turn to the network forces that can counteract the polarizing tendencies of influence and selection. These forces include the actions of formal administrators who might facilitate certain interactions among teachers or professional learning communities that provide opportunities for interaction. Formal administrators must also consider how their mediation of external forces affects the internal social dynamics of the school. Thus our chapter is partly an analysis of how informal networks complement or hybridize (e.g., teacher professional learning communities) with the formal organization. Such complementarities should contribute to higher quality, and more uniform teaching, and, ultimately, to the equity of educational opportunity.

We also recognize networks that transcend the school boundary, such as networked improvement communities and networks on social media such as Pinterest and Twitter. These forms challenge conventional conceptualizations of the school boundary as they are supported by infrastructures not defined by the formal organization of the school. As such, they can mitigate tendencies for inequitable opportunities, but only if carefully cultivated. We discuss that the ultimate challenge for any network form is how well it supports the primary process of teaching. As these forms may provide unique resources and potential for diffusion, they can contribute to higher levels and more uniform teaching that can mitigate otherwise unequal educational opportunities.

13.1 The Basic Structures and Processes of Social Networks[3,4]

At its most basic level, a social network consists of a set of nodes and edges connecting the nodes. For example, the nodes might be teachers in a

McPherson et al. (2001). For a motivation of network analysis from utility theory and a guide to the application of social network analysis see Frank et al. (2010).

[2]The social capital paradigm may also include factors such as norms that facilitate the flow of resources (Coleman, 1988). See Adler and Kwon (2002) and Kwon and Adler (2014) for reviews.

[3]Adapted from Frank et al. (2014).

[4]See Lima (2010) or Carolan (2013, chapter 4) for a description of methods for collecting and managing

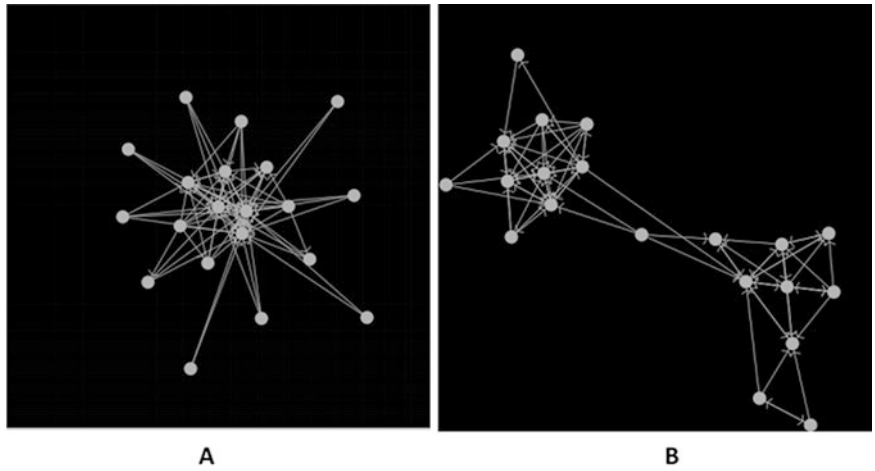

Fig. 13.1 Examples of network structures. (**a**) Core periphery structure in which a small number of actors engage in a large percentage of the edges. (**b**) Network clustering featuring regions of sparse and dense edges

single school and the edges might represent those teachers who are close colleagues. In this sense the edges represent a stable relation between the pair of actors/nodes.

13.1.1 Visualization of Networks

The structure of a network might then be defined in terms of the distribution of the edges between the nodes. For example, in Fig. 13.1 each dot represents a hypothetical actor (e.g., a teacher) and lines between dots represent actors connected to one another (e.g., teachers who are close colleagues or who share information with each other). A network might exhibit a core-periphery structure in which a small number of actors are engaged in a disproportionate number of edges (see Fig. 13.1a). Other networks might exhibit clustering defined by regions of dense and sparse concentrations of edges (see Fig. 13.1b).

These different structures will have implications for function. Informally defined cohesive subgroups can be critical for knowledge generation (Coburn et al. 2012; Bidwell and Yasumoto 1999) and the diffusion of innovations. For example, Penuel et al. (2009) compared two case studies, finding that the school that more successfully implemented a reform had better flows of expertise between subgroups. Subgroups also can constrain the ultimate diffusion of an innovation, as an innovation can become contained within the boundaries of a given subgroup. In such cases the diffusion ultimately depends on the action of those who bridge between clusters. More generally, core-periphery networks can diffuse innovations more rapidly and thoroughly than networks in which there are strong cliques, referred to as modularity (e.g., Csermely et al. 2013).

To give a sense of how the rate of diffusion is affected by the structure of a network, consider Figs. 13.2 and 13.3, originally used to study diffusion of technology into instruction in Westville High School (Frank and Zhao 2005). In the mid-1990s, the district central administration forced Westville to switch from Macintosh computers to Windows. To illustrate how the informal network shaped the organizational response, Frank and Zhao (2005) first used Fig. 13.2 to illustrate the informal structure of collegial ties among the teachers in Westville. Each teacher is represented by a number, and the lines indicate close collegial relationships obtained from the survey question, "Who are your closest colleagues in the school?" Frank's *KliqueFinder* algorithm identified the

high-quality data. For a review of reliability and validity of network measures see Marsden (2011), with improvement offered from Brewer (2000) and Henry et al. (2012), and specific to teachers in Pitts and Spillane (2009).

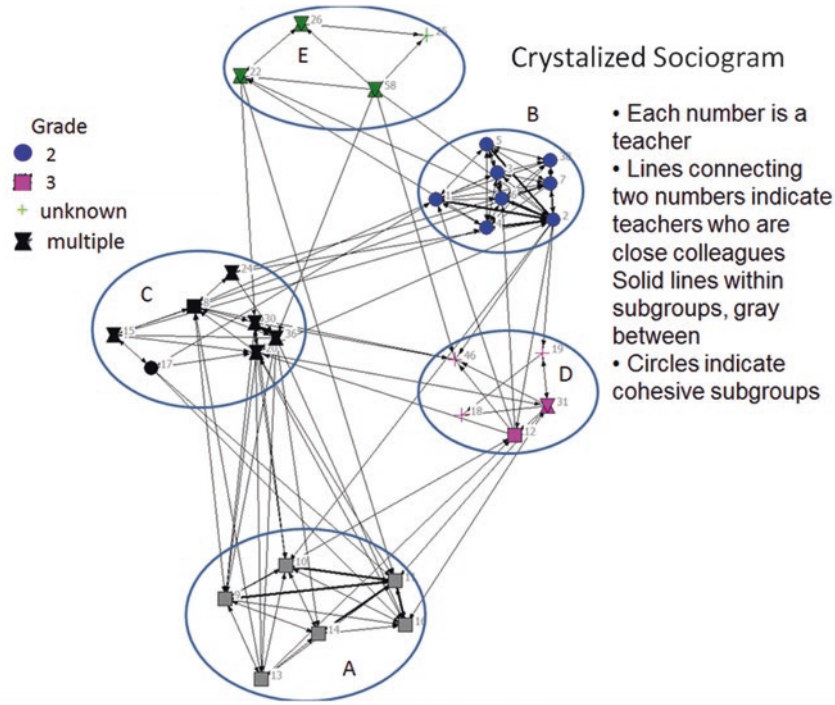

Fig. 13.2 Crystalized sociogram

subgroup boundaries in the image by maximizing the concentration of ties within subgroups versus between subgroups (see Frank 1995, 1996, for more details of the algorithm).[5] The black lines indicate within-subgroup (or cluster) interactions, while gray lines indicate between-subgroup interactions.[6]

The shape associated with each node in Fig. 13.2 indicates the grade in which the teacher taught. This information reveals an alignment of grade and subgroup boundaries. Subgroup A consists mostly of third grade teachers and subgroup B mostly of second grade teachers. But the subgroup structure also characterizes those faculty, administrators, and staff who do not neatly fit into the categories of the formal organization. For example, subgroup C contains the physical education teacher, a special education teacher, the principal, and two teachers who did not have extensive ties with others in their grades.

To relate the social structure in Fig. 13.2 to the flow of expertise about Windows and ultimately to changes in teachers' computer use, Fig. 13.3 represents interactions concerning use of technology (in response to the question: "Who in the last year has helped you use technology in the classroom?") with the location of the teachers still determined by the close collegial relations in Fig. 13.2. Generally the provision of technology support was concentrated within subgroups, especially the grade-based subgroups A and B. To represent the flow of knowledge or expertise, each teacher's identification number was replaced with a dot proportional to his or her use of technology at time 1 (a + indicates no information available). The larger the dot, the more the teacher used technology as reported at time 1. The ripples indicate increases in the use of technology from time 1 to time 2.[7]

[5]Available at https://msu.edu/~kenfrank/resources.htm#KliqueFinder.

[6]Directionality is not represented in Fig. 13.2 because close collegial relationships are used only to establish the underlying social structure. Arrowheads are used in Fig. 13.3 to show the flow of resources.

[7]Because the metrics varied slightly between administrations of the instrument, each measure of use was standardized

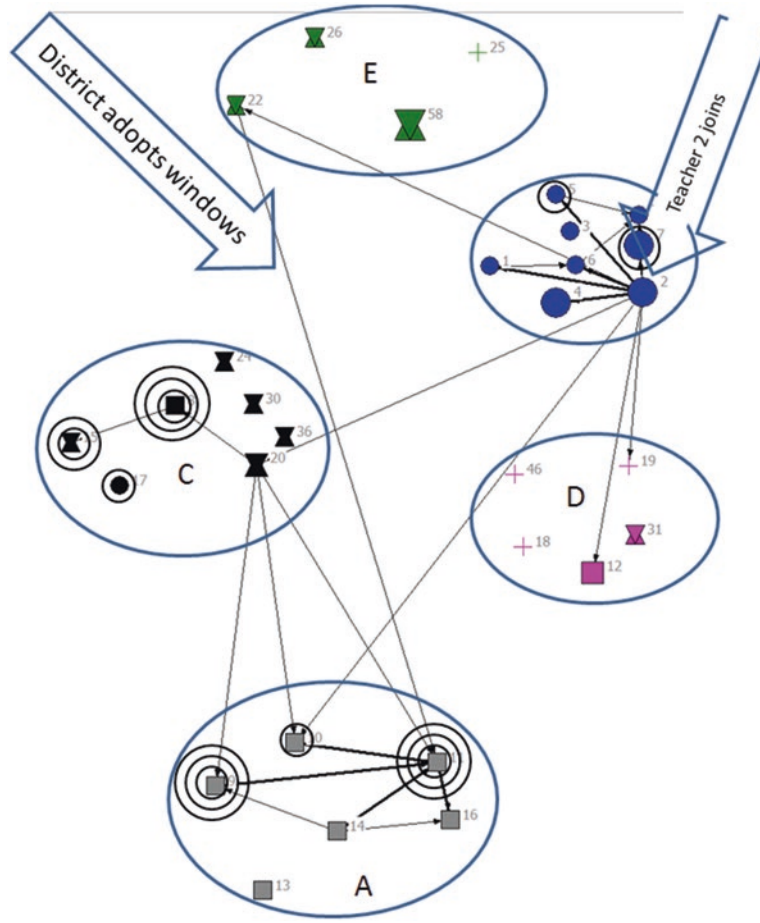

Fig. 13.3 Ripple plot

Ultimately, the story of Figs. 13.2 and 13.3 is one of the forms and distribution of social capital. In Fig. 13.3, intra-organizational diffusion essentially began when teacher 2 was assigned to Westville because of her expertise with the Windows platform. Teacher 2 immediately became a close colleague of other teachers in subgroup B, generating bonding social capital as she helped others in subgroup B with computer technology, resulting in some increments in technology use.

The key to extending teacher 2's knowledge beyond her subgroup was the bridging social capital (Atteberry and Bryk 2010; Daly et al. 2010; Penuel et al. 2009, 2010) between 2 and teacher 20, a veteran teacher in the school. Through teacher 20, the expertise of teacher 2 was disseminated to both subgroups C and B, resulting in substantial changes in use (e.g., as can be observed in the ripples around school actors in subgroup C). Without this bridging tie, teacher 2's expertise would likely have been confined to subgroup B, limiting the capacity of the school to implement technology, and potentially creating a cleavage in the social structure between subgroup B and the other subgroups.

Building on the results in Figs. 13.2 and 13.3, Frank et al. (2015) found in a longitudinal study across 21 schools that the distribution of resource flows between subgroups ultimately predicted a school's capacity to diffuse new teaching practices. In particular, schools that successfully cultivated expertise within a small number of

and then the difference was taken from the standardized measures. Each ring represents an increase of .2 standardized units.

subgroups (Nonaka 1994; Yasumoto et al. 2001), and then facilitated the flow of expertise from those subgroups throughout the school, more successfully implemented reforms than those in which expertise could emanate from almost any subgroup. That is, schools which manifest a cacophony of expert voices may find it difficult to implement and coordinate new practices, ultimately compromising educational opportunities for their students.

Graphical representations can intuitively demonstrate the information flow in a social organization and illustrate the process of change. But the application of social network analysis to educational research can extend these graphical representations by formally modeling the extent to which teachers are influenced through interactions with colleagues and what factors affect the ways in which teachers select with whom to interact.

13.1.2 The Influence Model

We begin the discussion of statistical modeling of teacher networks with the influence model (Friedkin and Marsden 1994), which can be used to estimate a teacher's implementation of specific teaching practices as a function of the prior behaviors of others around her (as a norm), and her own prior behaviors. For example, Frank et al. (2013b) modeled a teacher's implementation of skills-based reading instruction[8] as a function of her previous implementation as well as the behaviors of those with whom she frequently interacted regarding professional matters. Formally, let skills-based instruction$_i$ represent the extent to which teacher i implemented skills-based instruction. This is modeled as

$$\begin{aligned} &\textit{Skills}-\textit{based instruction}_i = \beta_0 \\ &\quad + \beta_1 \textit{previous skills}-\textit{based instructional} \\ &\qquad \textit{of others in the network of } i_i \\ &\quad + \beta_2 \textit{previous skills}-\textit{based instruction of } i_i + e_i, \end{aligned} \tag{13.1}$$

where the error terms (e_i) are assumed independently distributed, $N(0,\sigma^2)$. The term *previous skills-based instructional of others in the network of* i_i can simply be the mean or sum of the behaviors of those with whom teacher i interacted (e.g., as indicated in response to a question about from whom a teacher has received help with instruction). Using the mean as an example, if teacher Ashley indicated interacting with Kim and Sam who previously implemented skills-based instruction at levels of 25 and 30 respectively (representing the number of times per month the teachers used skills-based instruction for the core tasks of teaching), then Ashley is exposed to a norm of 27.5 (=[25+30]/2) through her network.[9] Correspondingly, the term β_1 indicates the normative influence of others on teacher i. If β_1 is positive, the more the members of Ashley's network use skills-based instruction, the more she increases her use of skills-based instruction. Corresponding to Fig. 13.3, if β_1 is large, then one would observe many ripples associated with teachers who interacted with others who had previously implemented skills-based instruction into their instruction.

Note that the inference of influence is indirect—Frank et al. (2013b) did not directly ask people who influenced them. Instead, influence is assumed if teachers change their behaviors in the direction of the average behavior of those in their network. Behaviors such as teaching practices and interactions can be more reliably and objectively reported than influence. A positive coefficient of β_1 indicates that the higher the level

[8]The skilled-based instructional practices include that teachers read stories or other imaginative texts; practice dictation (teacher reads and students write down words) about something the students are interested in; use context and pictures to read words; blend sounds to make words or segment the sounds in words; clap or sound out syllables of words; drill and practice sight words (e.g., as part of a competition); use phonics-based or letter-sound relationships to read words in sentences; use sentence meaning and structure to read words; and practice letter-sound associations (see Frank et al. 2013b, pp. 318–319 for details).

[9]In this sense, the exposure term extends basic conceptualizations of centrality (e.g., Freeman 1978) because the exposure term is a function of the characteristics of the members of a network, whereas centrality is a function only of the structure of the network.

of average implementation of a set of practices of those in one's network, the greater the likelihood of increasing one's own implementation. Furthermore, one may include covariates such as a teacher's attitude toward instructional practices representing a key predictor from the diffusion of innovation literature (Frank et al. 2013a, b, 2004; Rogers 2010). Frank et al. (2011; Penuel et al. 2012) also find that network effects are stronger for those who already have high levels of implementation.

Note the use of timing to identify the effects in model (1). The individual's outcome is modeled as a function of her peers' *prior* characteristics. This would be natural if one were to model contagion. For example, whether A gets a cold from B is a function of A's exposure to B over the last week and whether B had a cold *last week*. We would not argue that contagion occurs if A and B interacted in the last 24 h and both A and B got sick today (see Lyons 2011 and Cohen-Cole and Fletcher's 2008a, b critique of Christakis and Fowler's 2007, 2008 contemporaneous models of the contagion of obesity; see also Leenders 1995). Given longitudinal data, the influence model can be estimated with ordinary software once one has constructed the network term and controlled for prior engagement in the practice (see Frank and Xu 2018).[10]

Frank et al.'s (2013a, b) estimates of model (1) showed that teacher's teaching practices were influenced by those of her colleagues. Consistent with several other studies, teachers' influences tend to be small to moderate, but persistent across domains (e.g., Baker-Doyle 2015; Bidwell and Yasumoto 1999; Cole and Weinbaum 2010; Frank et al. 2004; Moolenaar 2010; Penuel et al. 2012; Spillane et al. 2001; Spillane and Kim 2012; Schneider 2015; Supovitz et al. 2010). Correspondingly, when networks are weak or sparse, innovations are unlikely to diffuse (Finnigan et al. 2013).

[10] See https://www.msu.edu/~kenfrank/resources.htm: influence models for SPSS, SAS, and STATA modules and PowerPoint demonstrations that calculate a network effect and include it in a regression model.

13.1.3 The Selection Model

While the influence model represents how actors change behaviors or beliefs in response to others around them, the selection model represents how actors choose with whom to interact or to whom to allocate resources. For example, the choices a teacher makes in helping others can be modeled as:

$$\log\left[\frac{p\left(help_{ii'}\right)}{1-p\left(help_{ii'}\right)}\right]=\theta_0+\theta_1 samegrade_{ii'}, \tag{13.2}$$

where p ($help_{ii'}$) represents the probability that actor i' provides help to actor i (similar to the influence model, these data can be obtained in response to a question about from whom teacher i received helped with instruction) and θ_1 represents the effect of teaching in the same grade on the provision of help.[11] As in the influence model, other terms could be included such as common grade taught, level of knowledge, etc. (e.g., Frank 2009; Frank and Zhao 2005; Spillane et al. 2012; Wilhelm et al. 2016).

Using this type of selection model, several studies have found that teachers receive help from close colleagues as well as others who teach the same grade (e.g., Frank and Zhao 2005; Gamoran et al. 2005; Penuel et al. 2010; Spillane et al. 2012; Wilhelm et al. 2016). Help also tends to flow from experts to novices (Coburn et al. 2010; Frank and Zhao 2005; Penuel et al. 2009), although the transaction costs of locating and engaging expertise are not trivial (Baker-Doyle and Yoon 2010; Spillane et al. 2017), and can be extreme when schools are under scrutiny for performance (Finnigan and Daly 2012).

[11] Estimation of model (2) can be challenging because of dependencies among the network ties. Techniques that control for dependencies through random effects (Baerveldt et al. 2004; Hoff, 2005; Lazega and Van Duijn, 1997) as well as latent spaces (Hoff et al. 2002; Sweet et al. 2013) have encouraging potential, although we note the focus of Exponential Random Graph Models on a relatively small number of geometrically weighted terms may address some previous concerns about degeneracies in estimation (Hunter et al. 2008). See Frank and Xu (2018), for more discussion.

13.1.4 Influence and Selection: Social Capital and Educational Opportunity

The processes of influence and selection complement each other in a social capital exchange (Blau 1968). In the social capital exchange between teachers (Frank et al. 2004), teachers trade their conformity (i.e., accepting influence) for access to knowledge, expertise, and support in a form of social capital exchange (i.e., selection of the provision of help). As a result, those teachers less in need of local knowledge, support, and expertise will be less compelled to conform to the norms of their colleagues. This might apply to a veteran teacher who already has extensive local knowledge and whose employment and success do not depend on conformity. It might also apply to a participant in alternative certification such as Teach for America who does not intend to remain in a school for more than a few years. On the other hand, novice teachers who have extensive need for local support and knowledge may find the norms of their colleagues compelling.

Ultimately, the processes of influence and selection work in tandem to distribute the key resource of expertise and provide organizational coordination through conformity. But unchecked, the processes of influence and selection can contribute to inequitable opportunities for education. To begin, if teachers are organized into clusters or subgroups (e.g., Fig. 13.1b; Frank and Zhao 2005; Frank et al. 2015), and teachers are influenced by their colleagues early in reform implementation (Camburn et al. 2003; Coburn 2005; Coburn et al. 2012), then reforms will not diffuse evenly and can even polarize a school (Frank et al. 2013a, b). More generally, processes of influence may exacerbate initial differences in teaching quality if high-quality teachers select to interact with other high-quality teachers with equal status or with whom there is an equal exchange.

Differences in the quality of teaching create a situation in which more advantaged students can leverage their backgrounds to navigate to higher-quality teachers, creating a mechanism through which initial advantages accumulate through intra-school dynamics. Furthermore, even if all teaching is of equally high quality, differences in the type of teaching can create learning challenges as students transition from one classroom to another from one year to the next (as in an elementary school) or 1 h to the next (as in a high school). The more support a child has in the home (in terms of parental education or capacity to navigate to teachers with good fit) the better the child will be able to adapt. Although there is great value in teachers learning from each other, if the learning is concentrated within specific pockets the attendant social dynamics may contribute to differences among teachers that may not be benign.

13.2 Network Forces That May Mitigate Inequities of Educational Opportunity

We now represent network forces that contribute to and may mitigate inequitable educational opportunities. Consider Fig. 13.4 in which we depict 3 teachers and 3 students within a single school. The black lines represent the assignment of students to teachers, one of the fundamental functions of a school (Dreeben and Barr 1988; Bidwell and Kasarda 1980). We represent potential stratification in a laissez faire system with the less eager (or less advantaged) student in the middle assigned to the less knowledgeable and less effective teacher on the left. On the bottom, the student might draw on his student network (blue line) for support or to gain assignment to a different teacher. While this may be an effective adaptation for the particular student, it does not mitigate the underlying inequities among the teachers which generally contribute to the conditions for inequitable opportunity. As we have presented above, differences among teachers can be reduced if teachers of different style and levels of expertise interact with one another, as shown by the blue arcs in Fig. 13.4.

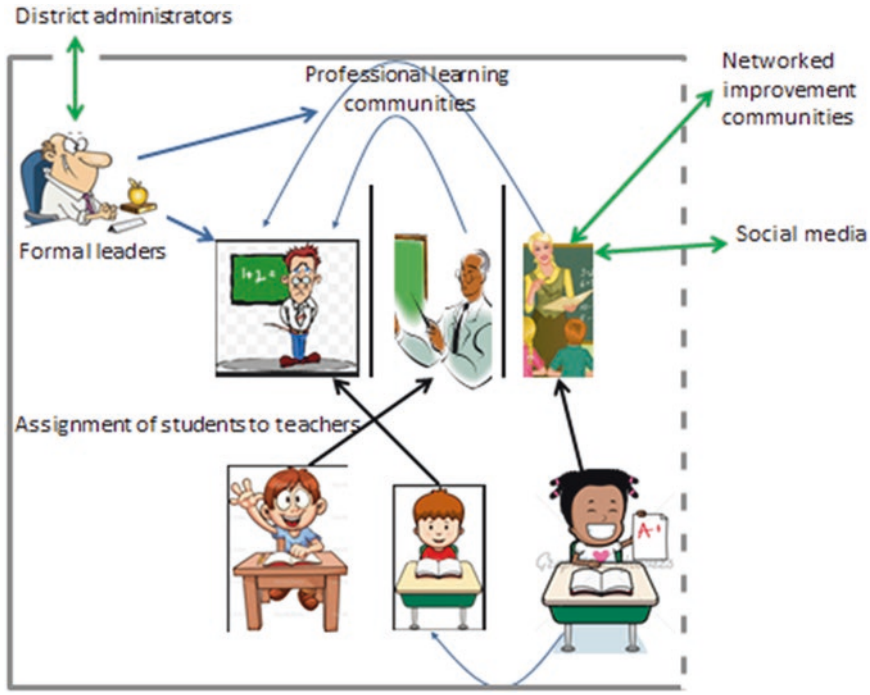

Fig. 13.4 Teacher networks and equity of opportunity

13.2.1 Effects of Formal Networks and Formal Leaders on Teachers

As shown on the left of Fig. 13.4, the school may organize network flows through the designation of formal assignments. For example, because teachers typically seek advice from others in the same grade or subject, as administrators make instructional assignments they shape teacher networks. Correspondingly administrators should consider the attendant diffusion of expertise in making those assignments.

Formal leaders may also directly affect teacher's networks through brokering advice-seeking networks (Spillane and Kim 2012). Differences among teachers may be further mitigated through interactions outside the gray dashed line of the school boundary such as with networked improvement communities or social media. Critically, these supports and knowledge must be adapted and reconciled with the intra-school network (Coburn and Russell 2008; Daly, Moolenaar, Bolivar et al. 2010; Frank et al. 2011; Frank et al. 2013b). In the sections below we elaborate on each of these processes.

Administrators may also affect professional networks by designating certain teachers for formal roles. For example, Coburn and Woulfin (2012) found that coaches were some of the strongest influences on changes in teachers' instructional practice when a new policy message was introduced. Interestingly, some of the stronger effects of coaches may be in promoting knowledge flows among others in the school (Coburn and Woulfin 2012; Sun et al. 2013a, b; Sun et al. 2014). Ultimately, the strength of a teacher's informal connection to formal leaders predicts student achievement (Friedkin and Slater 1994; Pil and Leana 2009), possibly mediated by sense of efficacy (Moolenaar et al. 2012), use of data (Daly 2012), and commitment (Thomas 2007).

Formal leaders may also facilitate teachers' instructional learning by creating opportunities and regulating general instructional practices (Coburn et al. 2013; Daly et al. 2010, p. 375); Sun et al. 2013a; Hopkins and Spillane 2014; Supovitz et al. 2010). For example, principals

and coaches can influence the social process of understanding reform by framing the meaning of the reform (Coburn 2005; Sun et al. 2014). Formal leaders may also be critical to maintaining existing network ties (Spillane and Shirrell 2017). In this sense, formal leaders create the norms and conditions that support the flow of social capital (Bryk and Schneider 2002; Coleman 1988). As they do so, formal leaders may indirectly affect the networks through which teachers interact, creating a potential counterbalance to any tendencies for polarization in teachers' networks.

Of course, the external contexts of schools can exert polarizing forces within schools as schools react to competing external demands (e.g., Coleman 1961; Powell et al. 1985). Leaders can be a conduit or buffer for external pressures, partly depending on their networks (Daly et al. 2010; Rigby 2016). For example, principals who were central in both intra- and inter-school networks played critical roles in diffusing innovations from outside the school to the school, and then within the school (Moolenaar et al. 2010b; Moolenaar and Sleegers 2015; Hopkins et al. 2013). Furthermore, Leana and Pil (2006) found that administrators' ties to the external environment predicted student achievement, possibly because poor network ties impede the formation of trust and exchange of critical support (Daly and Finnigan 2010).[12] Of course given the demands of engaging in in-depth interactions (Coburn and Russell 2008) it may be difficult for formal leaders to maintain high centrality within and outside of a school (Moolenaar and Sleegers 2015; Atteberry and Bryk 2010; Coburn and Russell 2008; Cole and Weiss 2009; Frank et al. 2013b; Spillane and Kim 2012; Spillane and Healey 2010).

The interplay of formal and informal processes raises an interesting proposition about the primacy of either (Selznick 1948; Sun et al. 2013a). On one hand, informal interactions among teachers can affect teachers' commitment and sense of efficacy (Hong et al. 2013; Pogodzinski et al. 2013; Pogodzinski et al. 2012). On the other hand, implementation of reforms certainly depends on the direct support of formal leaders (Daly and Finnigan 2016). Ultimately, schools are likely more effective when formal and informal are aligned (Penuel et al. 2010; Spillane et al. 2010). But our analysis would suggest that principals would want to carefully guide the intra-organizational diffusion process so as not to exacerbate existing differences in expertise or teaching style among teachers.

13.2.2 Teacher Professional Learning Communities: Mid-Ground Between Formal and Informal

While the school formally shapes teachers partly through professional development (Garet et al. 2001; Desimon et al. 2002), the school also shapes teachers through informal networks of teachers. As shown at the top of Fig. 13.4, teacher professional learning communities (PLCs) occupy a mid-ground between the formal and informal organizations (Gamoran et al. 2005; Hord 1997; Resnick and Scherrer 2012; Wood 2007). PLCs are established by the formal organization and leaders, with designated membership and venues for interaction (Achinstein 2002; Fullan 1993; Lave and Wenger 1991). But once established, the interactions within the PLC may be wide-ranging and informal as teachers explore ways to learn from each other and improve instructional practices.

The informal processes in PLCs offer opportunities for teachers to develop norms and trust in one another so they may have frank professional exchanges that lead to learning (Stoll and Louis 2007; Bryk et al. 1999; Daly et al. 2010; Moolenaar et al. 2012). Ultimately these norms can have far-reaching effects into the culture of a school, affecting the capacity of the school to implement effective teaching (Bidwell and Yasumoto 1999; Leana and Pil 2006) and innovations (Moolenaar et al. 2010a, b) creating educational opportunities for students attending the school (Bryk and Schneider 2002).

[12] Although formal ties tend to be weakly related to use of evidence (Daly et al. 2014a, b).

The importance of the norms highlights the location of the PLC in the mid-ground between the formal and informal organization. To build trust and develop a norm of learning means that vulnerabilities will not be exploited or sanctioned. Consequently, formal leaders must support informal, deep conversations without exploiting such conversations for the purposes of evaluation (Coburn and Russell 2008). This may be especially challenging in schools that face extreme accountability pressures (Rigby et al. under review), potentially introducing norms counter to those that cultivate sharing and trust (Bryk and Schneider 2002; Frank et al. 2008).

As PLCs occupy a mid-ground between the formal and informal organization, the study of PLCs partly engages conventional network analysis of interactions among teachers. But within the context of a PLC it is difficult to know the directionality of interaction. Typically all who are present are exposed to the member who speaks at any given time. This is in contrast to typical network analysis focused on one-to-one professional conversations, advice seeking, or knowledge sharing. Correspondingly, studies of PLCs often focus on the relationship of members to the collective of the PLC (Goddard et al. 2007; Louis et al. 1996; Ronfeldt et al. 2015), whereas studies of teacher networks typically focus on resources that flow through specific relationships to specific teachers.

Frank (2009) offers a potential synthesis of the one-to-many (e.g., PLC) and one-to-one (e.g., conventional teacher network) paradigms, arguing that a relationship with a group of people as a collective generates quasi-ties. Quasi-ties between a person and a group can direct the flow of resources evenly throughout the group, overcoming the tendency for people to favor allocations of resources (e.g., expertise) to specific others with whom they have a direct personal relationship. In this sense, PLCs can contribute to the even distribution of resources throughout a school, overcoming the tendency for resources such as expertise to become concentrated in specific pockets or teacher cliques. As a result, the PLC can contribute to more coordinated and even teaching, and thus to more equitable educational opportunities.

The study of PLCs can also offer potential insight into the substance of professional interactions. It is rare for those who study teacher networks to directly observe and record conversations among teachers which may be very intimate from a professional standpoint. But researchers have gained access to PLC meetings in their slightly more open venues. In one such study Horn and Kane (2015) showed not all PLCs are equally conducive to teachers' learning. The richer PLCs had more conversations, featured richer conceptualizations and specific future work (Horn and Kane 2015). Recent work also suggests that PLCs with deeper interactions are more likely to foster one-to-one professional interactions outside of the PLC than are PLCs with lower quality of interaction (Horn et al. 2017). This demonstrates the complex social position of the PLC, with the substance and process determined in part by formal leaders, and in turn affecting the informal networks that reside outside the PLC.

13.3 Crossing the School Boundary

13.3.1 Effects of External Institutions on Teacher Networks

Following the long history of the study of schools relative to their environments (Bidwell and Kasarda 1987; Callahan 1962; Greenfield 1975; Meyer and Rowan 1977; Rowan 1995), the intra-organizational networks of schools can be affected by forces external to the school. Daly and Finnigan (2010, 2011) and Wilhelm et al. (2016) found that in schools facing accountability pressures teachers sought math-related expertise from those with high value-added scores over those whose practices featured ambitious math instruction or who possessed high levels of mathematics content knowledge (Rigby et al. 2014). Coburn et al. (2010) found teachers sought others with specific expertise related to the implementation of a new reform, while Supovitz et al. (2014) found that teachers sought expertise from colleagues and administrators about the common core.

Examining the implications of external institutions on school networks, Frank et al. (2013b) identified subgroups or cliques of teachers at the onset of institutional pressures associated with NCLB (e.g., emphasis on skills-based instruction). As teachers responded to the practices of others in their cliques the cliques became more differentiated. Thus, the pressures of "No Child Left Behind" ultimately contributed to polarization among teachers within their schools. Such polarization can create immediate challenges to the coordination of teaching, which can then affect educational opportunities within schools as well each school's capacity to implement future reforms. Bridwell-Mitchell and Sherer (2017) extend this to the development of institutional logics within subgroups that then shapes teachers' reactions to external institutions.

13.3.2 District Administrators as Bridgers

In general, district administrators (shown at the top left of Fig. 13.4) span the boundary between schools, outside institutional forces and the community (Daly et al. 2014; Honig 2003, 2006; Hite et al. 2005). Critically, when a school or district leader holds a more central position in the social network, he or she has more influence in the organization as well as increased access to resources (Daly et al. 2014b). But district administrators must carefully manage their position in informal networks, which can be quite fluid (Daly and Finnigan 2011; Honig 2003, 2006) and in which churn can create challenges for developing trusting or deep relationships.

Michigan offers a particularly interesting case of the administrator as boundary spanner (Spillane 1996). Beginning in the 1980s Michigan expanded state-level testing (MEAP test), and state-level legislation revised the state's learning standards and tied financial sanctions to district failure to align their curriculum to the state model. The district's response to such policies depended heavily on the district administrators (Spillane 1996). For example, one district used district policies to buffer teachers from state policy by preserving more skills-based reading instruction, while another mobilized resources to promote more ambitious reading instruction aligned to the new state policy (Spillane 1996).

There is an important tension between forcing immediate responses versus buffering teachers to provide opportunities and a culture for teachers to interact, share knowledge and coordinate contributing to equitable opportunities. For example, Daly and Finnigan (2011, 2010) found that in schools under accountability policy sanctions, school leaders' interactions tended to focus mainly on reform strategies over innovative practices. As a result, newcomers to the network who could bring innovative knowledge were kept on the periphery. Also, school leaders remained on the periphery, while central office staff held more central positions, resulting in most knowledge flowing within and throughout the central office rather than to the school sites. Thus, administrators' decisions can accumulate to limit other informal networks and resource flows within the district. Ultimately, these limitations restrict the flow of knowledge, contributing to differences in expertise that can affect educational opportunities.

13.4 New Network Forms That Transcend School Boundaries

13.4.1 Networked Improvement Communities

Recently administrators and policymakers have begun to attend to inter-district entities that draw on network dynamics to improve schooling outcomes—Lieberman (2000) (e.g., the green lines at the top left and top right of Fig. 13.4). For example, the National Writing Project (NWP) organizes summer institutes in which teachers from different schools share their best lessons and teaching strategies, engage in the writing process, participate in writing groups, and receive peer feedback (Lieberman and Wood 2002; Little 2006; National Writing Project 2016). After a

teacher successfully finishes the summer institute, he or she becomes a teacher consultant, bridging between the NWP and local school communities. Some lead professional development in their schools, while others join local leadership teams to help create special interest groups relevant to teaching writing (Lieberman and Wood 2004). In fact the spillover effects of the NWP on others in a participant's school may be as great as the direct effects on the teachers who participate in professional development (Penuel et al. 2012; Sun et al. 2013b).

Recently Bryk et al. (2015) have extended models such as NWP to propose a general model of Networked Improvement Communities (NIC). Analogous to the PLCs within a school, NICs between schools carefully cultivate the types of interactions that support collective learning and knowledge sharing. In particular, the NIC process consists of a series of cycles of Plan-Do-Study-Act (PDSA). Explicitly stating the need to cycle through PDSA lays the foundation for teachers to share their vulnerabilities and invest in one another. Furthermore, over multiple PDA cycles networks can be expanded to include new school staff. For example, in the later PDSA cycles of the BTEN NIC, members of a principal group began their own cycles of PDSA (Bryk et al. 2015).

While the PDSA of NICs holds great potential for generating and diffusing knowledge about teaching practices, teaching practices advocated in inter-school networks may conflict with the norms of a particular school as on the right hand side of Fig. 13.4. Part of the test of the NICs is how they can systemically support the integration of knowledge into the school. Indeed, design based research attends to networks partly to facilitate this transfer (Cobb and Jackson 2011; Russell et al. 2013). Furthermore, the knowledge itself may be transformed as it permeates the school boundary (Frank et al. 2011). Critically, failure to meld extra-school knowledge with intra-school norms can create coordination challenges and unequal instruction within schools that can lead to inequitable opportunities to learn.

13.4.2 Social Media: The Case of Pinterest

The evolution of educator networks now includes entities formed on social media (e.g., see http://www.hashtagcommoncore.com/; Noble et al. 2016; see Macià and García 2016 for a review of online professional communities). These entities challenge standard distinctions between formal versus informal networks because they may be formed deliberately, may emerge organically, or may be facilitated through data mining algorithms, programmed to connect a set of participants with shared interests. Similarly, social media networks challenge standard distinctions between intra- and inter-school networks as participation is not easily defined by the school boundary.

While teachers may use various social media (Facebook, Twitter), a set of recent studies has focused on Pinterest, a personalized social media platform, because it is one of the most frequently used social media platforms by teachers (Kaufman et al. 2016). Pinterest allows users to "pin" pictures or videos (posted by others or found by themselves) to organize and save for future reference. Evidence from a recent study focusing on early career teachers (ECTS) suggests that the Pinterest platform creates a discourse community for teachers that is different from the traditional face-to-face interactions ECTs have with their colleagues or in PLCs (Torphy et al. 2016a). A second study shows how ECTs purposely choose worthwhile sources of information (Torphy et al. 2016b). In particular, entrepreneurial teachers (called teacherpreneurs), seek out other teacher practitioners in the pursuit of exemplary teaching resources, practices, and pedagogy. Furthermore, data from Pinterest can provide valuable insights into what teachers are thinking, how they change their practices, and who they learn from as they do so (Hu and Torphy 2016; Torphy and Hu 2016).[13]

[13] Given the recent emergence of the phenomenon, many of the studies we report on here are in early stages, such as conference presentations, but not yet published in peer review journals.

There are three fundamental challenges to the realization of the potential of social media networks. First, as with the challenge for other extra-school networks, the challenge for teachers' use of social media will be in how interactions through social media meld with professional interactions within the school (Cho et al. 2013; Cho 2016). For example, materials and resources accessed on Pinterest may not conform to state or district adopted standards, or with teaching norms within a school. The teacher must then navigate the use of the resources given her local context. This is not an insurmountable challenge, but requires teachers' professional judgment.

Second, one must consider the motivation for teachers to provide their expertise and help to others via online social media. A small number of teachers may do so for remuneration (e.g., https://www.teacherspayteachers.com/). Others may do so for status as in traditional social exchange (Blau 1968). But social exchange depends on the visibility of the exchange and the extent to which the provider values status as part of her identity. Currently, sites like Pinterest make exchanges known in the form of publicizing followers. How much teachers identify with these sites is less known. As social media become increasingly salient with each new cohort of teachers social media identities may increase. Nonetheless, a social media identity must compete with identification with the school organization with whose members a teacher shares students, common evaluation, and therefore the form of social capital known as bounded solidarity (Portes and Sensenbrenner 1993).

Third, there is the concern regarding educational opportunity and online networks. On one hand, online networks may provide teachers in disadvantaged settings or teachers with relatively less training or skill access to critical resources that can make them better teachers. This can contribute to more equitable educational opportunities. On the other hand, if existing advantages in skill or resources make it easier for teachers to access online resources and integrate them in their classrooms, then the diffusion of online resources can contribute to stratification just as any other resource can.

13.5 Discussion

Most sociology of education has focused on the resources to which students have access and the equitable distribution of those resources. To be sure, such resources as family education and income contribute directly to the opportunities students have to learn in the home and school. But a key aspect of the family resource determines the school the children attend. And a critical resource of the school is the quality of the teaching (e.g., Nye et al. 2004). As a direct result, differences among teachers within and between schools contribute to inequities in opportunities within and between schools.

There are various policies and practices that can reduce differences among teachers. Professional development and support can help relatively less effective teachers improve. Policies that include incentives or merit pay can attract and retain high-quality teachers, especially in schools serving at-risk students. On the other hand, policies that evaluate individual teachers in terms of value-added scores encourage competition among teachers and discourage cooperation, which can exacerbate existing differences.

But teachers can also be key resources for one another. As such, teacher networks can distribute expertise and support that can mitigate existing differences in teacher quality. Networks such as NICs or online (e.g., Pinterest) outside of schools can provide teachers and administrators with general knowledge about learning, or ideas for teaching. Networks within schools can provide teachers with local knowledge about how to implement a curriculum within the school context and for a particular student population.

While networks have great potential to mitigate existing differences among teachers, they will likely not realize that potential if they are allowed to emerge without explicit attention to the consequences for equity. Left to their own devices, humans are likely to seek homophilous others with whom the transaction costs of interacting are low (Zeng and Xie 2008; Frank et al. 2013a) or to cultivate interactions with those with whom they can establish an exchange (Blau

1968). These natural tendencies can accentuate baseline differences among teachers.

But deliberate action can mitigate natural tendencies for resources to become concentrated in certain schools or among certain teachers within a school. Formal and informal leaders can provide direct supports for novices or teachers who are struggling. Moreover, formal and informal leaders can cultivate relationships among others that contribute to the even distribution of expertise within and between schools. This might occur through leaders' choices of mentors for novice teachers or those performing inadequately. It may also vary by subject or context, tapping different teachers' expertise in a particular subject or pedagogical technique.

It is likely that effective formal and informal leaders tacitly tap the potential of networks for the creation and distribution of expertise, and for coordinating action among teachers. But here we make the process explicit and link it directly to the underlying distribution of opportunities for education. By doing so we contribute to the language of social capital for describing schools as social organizations, with the ultimate goal of helping all schools cultivate expertise and distribute educational opportunities equitably.

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