Knowledge Management and Human Resource Development: An Application in Social Network Analysis Methods

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The problem and the solution. This article describes how social network analysis (SNA) can contribute to the knowledge management (KM) efforts of human resource development (HRD) professionals in organizations today. The suggested contributions of SNA are based on primary research conducted across more than 80 organizations. The author first provides an introduction to the people-to-people strategy of today's KM efforts. A detailed look at some common HRD challenges is introduced. Next, an introduction to SNA metrics and techniques is given, and a description of how they can be used to help understand HRD challenges is outlined. The author then provides three cases to illustrate how SNA can aid HRD analysis and interventions involving (a) knowledge creation and innovation, (b) knowledge transfer and retention, and (c) knowledge associated with job succession planning. The author concludes by discussing the implications for HRD of utilizing SNA in the organization.

Keywords: *social network analysis; knowledge management; HRD; innovation*

During the past decade, the focus of knowledge management (KM) initiatives has shifted from a strategy of capturing data and explicit information in portals and databases to a strategy of promoting tacit knowledge sharing among people (Cross, Parker, Prusak, & Borgatti, 2001; Davenport & Prusak, 1998). Initial KM initiatives were mostly based on information technology (IT), including repositories that captured critical documents such as lessons learned and best practices. However, many of these early initiatives failed for several reasons: out-of-date documents stored in the repositories; knowledge documents not fitting exactly to the employee work process and need; and rewards, incentives, or company cultures that discouraged document sharing (Douglas, 2002). Although IT certainly has been (and will remain) a critical component of KM

projects, KM initiatives should also include strategic, process, and people components to achieve successful outcomes (Davenport, DeLong, & Beers, 1998). Examples of these components include top-manager support, changes in motivational practices, and recognition that knowledge is transferred through multiple channels including face-to-face interactions. Communities of practice (Cohen & Prusak, 2001; Wenger, 1998) is evidence of a shift to a more people-focused strategy, and it has become an increasingly popular KM initiative that emphasizes the connections among people with a common passion and interest area. The main advantage of a people-focused strategy is that it enables the sharing of more relevant tacit knowledge (Polanyi, 1983), such as employees' experiences, know-how, and other similar or complementary expertise that cannot be captured in documents.

Today's organizations require the capability to access timely expertise, and this is most likely done through employees' personal or social networks—the informal connections and relationships among people where much knowledge sharing occurs and very often where critical work gets accomplished (Gubbins & Garavan, 2005; Storberg, 2002). Work in organizations has become much more relational, interdependent, and collaborative in nature, and therefore an appropriate lens is needed through which to examine the interactions among employees (both within and outside the firm) that enable work to be accomplished (Cross & Parker, 2004).

As a result, there has been an exponential rise in the use of social network analysis (SNA)—a methodology that analyzes the relationships among actors, such as employees, in a network context—to study research areas in several disciplines, including management (Andrews & Knoke, 1999; Borgatti & Foster, 2003; Wasserman & Faust, 1994). Included here are areas such as leadership (Brass & Krackhardt, 1999), entrepreneurship (Baron & Markman, 2003), and creativity (Perry-Smith & Shalley, 2003). SNA provides a lens through which to view the structure of work networks, to identify where barriers between individuals and groups might exist that may be inhibiting communication and collaboration. The methodology also identifies individual positions in the network, such as central, peripheral, and broker roles that bridge different groups, which can facilitate both the discovery of problem areas and opportunities for interventions.

I next describe the research context that was used to conduct the SNA analyses in this research. As part of network analysis and KM research done at the Network Roundtable consortium at the University of Virginia and the Working Knowledge consortium at Babson College, the research team conducted SNA studies in more than 80 organizations across multiple industries including technology, manufacturing, finance, energy, consumer products, and governments. The team mostly focused on networks ranging from 25 to 300 people that span multiple geographic, hierarchical, and work functions within and across organizations. Network data used in management research are most commonly obtained through surveys answered by respondents in the network,

although they can also be obtained through tracking e-mail, data flows, or secondary data. Research referred to in this article predominately relied on survey-based methods to collect network data. The UCINET software program was used to analyze the data, and the NetDraw program was used to show the visual representation of the network (Borgatti, Everett, & Freeman, 2002). Also, as part of the SNA with each organization, interviews were conducted with both survey respondents who hold key positions in the network and organizational stakeholders to gain qualitative insights on their current network and to discuss future action items or interventions to improve the network.

This article provides an introduction to SNA methods and how they can be applied to the KM requirements of human resource development (HRD) practices. First, a brief overview of some common HRD challenges is introduced, along with a description of how a network perspective can provide a useful lens to understand these challenges. Next, an introduction to SNA metrics and techniques is given, and a description of how they can be used to help understand HRD challenges is provided. A main contribution of this article is to focus the discussion of SNA on topics relevant to the KM requirements of HRD professionals and then to provide three cases to illustrate how SNA can aid HRD research and practice. I conclude the article by discussing some future HRD research and managerial implications of utilizing SNA in the organization.

HRD Challenges and SNA

The HRD field can benefit from understanding the processes and practices associated with KM (Gourlay, 2001), particularly where it improves employee performance and effectiveness. One of the challenges that HRD and human resource management (HRM) professionals face is the transfer of knowledge, both explicit and tacit, among employees, teams, departments, and divisions (Gourlay, 2001; Kubo, Saka, & Pam, 2001). Two main strategies for knowledge sharing are a codification strategy and a personalization strategy (Hansen, Nohria, & Tierney, 1999). A codification strategy relies on the reuse of explicit knowledge, including documents such as previous work project reports, lessons learned, and best practices. This codification strategy is aligned with Wenger's (1998) participation and reification processes found within communities of practice. It is also aligned with practice-based learning. By leveraging existing work, the organization can be much more efficient as a result of "not reinventing the wheel" and learning from past experiences. IT plays a major role by capturing and retaining these explicit documents in repositories and portals. Meanwhile, a personalization strategy focuses on the people-to-people connections, where the objective is for employees to connect to experts and their tacit knowledge including experiences, skills, and know-how on a real-time basis. Organizations that need their people to find critical experts on a real-time basis, such as consulting organizations that are trying to win a client engagement or an oil company that has a crisis situation at one of its drilling sites, need to know who

the "go-to" people are. Although certainly both strategies can coexist within any organization, the companies analyzed for the research illustrated in this article heavily rely on personalization strategies for accessing and transferring knowledge. Consequently, SNA is very useful in informing the design of this strategy.

SNA can influence HRD interventions at the individual, group, and organizational levels. Adopting a relational or network perspective to analyze these processes and practices facilitates greater understanding of these HRD processes (Hatala, 2006). For example, the performance of individuals can be affected by their position (e.g., central employees who have many direct connections to other colleagues) in the organization's work network (e.g., Cross & Cummings, 2004; Mehra, Kilduff, & Brass, 2001). Also, it is important to understand the nature of the work task (e.g., a task involving innovation) as it relates to a person's network (e.g., Brass, 1995; Perry-Smith & Shalley, 2003). These have implications for HRD interventions that aim to improve employee effectiveness and performance through training, mentoring, and newcomer orientation and acclimation initiatives by underscoring the importance of getting employees connected to subject-matter experts and key decision makers. At the individual level, SNA facilitates the identification of those who are central or brokers in the work network and employees on the periphery. This helps HRD professionals to devise interventions for knowledge acquisition, transfer, and retention among individuals. Central employees who are subject-matter experts or key decision makers can be paired with peripheral people as a part of a mentoring or newcomer orientation initiative for the purpose of transferring tacit knowledge (e.g., central person's expertise, experiences, institutional memory) and getting the newcomer quickly acclimated to the work network by facilitating relationship building (Rollag, Parise, & Cross, 2005).

Many HRD professionals are asked to design interventions to retain critical knowledge (DeLong, 2004; Salopek, 2005). If a company does have a retention strategy for capturing knowledge, the strategy usually involves capturing work documents or conducting exit interviews with senior people before they leave the company. The problem with this approach is that even if this knowledge is made available in repositories, it often becomes "stale" and ineffective without talking to the source of that expertise about its context. What an organization misses most, especially those who rely on a personalization strategy, are the critical relationships that departing employees take with them and what that does to the informal work network of the organization (Parise, Cross, & Davenport, 2006). SNA is a lens through which to see what would happen to a company's network if critical people—central people and brokers—were to depart. Individuals who are central or play a broker role in the network can be targeted as part of a knowledge-retention program (Parise et al., 2006). As part of the retention program, HRD professionals can capture not only what these key individuals know but also whom they know in terms of critical relationships.

The rate of employees succeeding in new job positions, especially those in leadership positions, has not been very good (Fisher, 2005). One of the reasons

for this is access (or lack thereof) to critical expertise to perform well in this new job position, as it is often relationships that are needed (but missing) to gain this required knowledge (Rhee, 2004; Vollhardt, 2005). Although new employees and leaders may have a good understanding of the job description and the technical expertise underlying the job, what they lack are the personal networks or relationships needed in the context of the new job. An analysis of employees' personal network—in terms of who is in their network and what types of expertise are available in the network—is a great learning tool for employees in terms of individual coaching and job planning. HRD professionals can conduct workshops and walk participants through the process of identifying their personal network (e.g., "Who are the people you go to for help at work?"), understanding the network profile (e.g., "Most of your relationships are with subordinates for the purpose of getting status reports"), and discussing any biases or areas for improvement (e.g., "No one in your network helps you with budget negotiations, which is critical for your job").

At the group level, HRD professionals can help business managers analyze and diagnose causes of intergroup fragmentation and discuss action items to overcome these challenges. Connections within groups, connections with other groups, and group leaders' connections with peers and higher-level managers can have an impact on group performance (Mehra, Dixon, Brass, & Robertson, 2003; Oh, Chung, & Labianca, 2004; Reagans, Zuckerman, & McEvily, 2004). This has implications for HRD professionals (and other business managers) responsible for project staffing (especially leadership positions) and ensuring communication and coordination between group projects and business units.

An SNA analysis of different work groups (e.g., business units, divisions, departments) can help determine if the level of knowledge sharing within and between groups is sufficient. At points of fragmentation in the network, HRD professionals can assign individuals to "broker" roles to facilitate communication between groups and to ensure that critical expertise and decisions get passed along to the right people. HRD professionals can also help staff groups, in particular leadership positions on project teams or communities of practice, based on an SNA assessment. Employees identified as being central or brokers from the network analysis are ideal candidates to lead a work group or community, especially if the group is cross-functional, consisting of people from different areas of the business, and the targeted leaders have established relationships in these areas. Or, if the organization deems brokers to be a critical position, HRD can look to develop employees for this role. Effective brokers have a good understanding of multiple work groups, so job rotation of certain employees may be an effective personal development strategy.

In addition, SNA can aid HRD professionals in enabling an organization's innovation efforts. Most innovations of any substance are inherently collaborative efforts. In both the inception of an idea and its implementation, networks play a critical role in integrating relevant expertise and facilitating coordination of work. This "networked" view of innovation significantly differs from the belief that
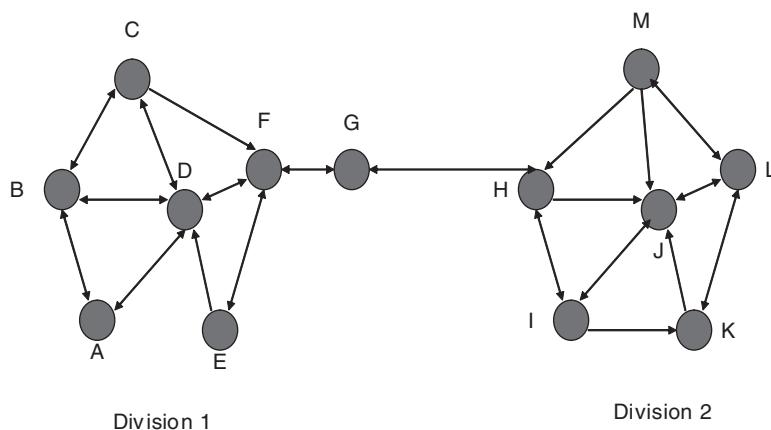
FIGURE 1:   Basic Network Structure

knowledge creation is achieved by a single individual expert or that the process is serendipitous and difficult to replicate (Hargadon, 2003). Network analysis can provide a lens through which to view how work and information flow are occurring across groups to determine if unique expertise is being integrated in ways that an organization requires to serve certain markets and develop or extend given products or services. By mapping connectivity among experts and decision makers, managers can take concerted action to ensure the appropriate pattern of collaboration. Based on the SNA research used for illustration in this article, in organizations where knowledge creation was a main objective, it was found that there are certain network roles that are critical in the innovation process: a group of experts who are responsible for developing a new idea or enhancing an existing idea, a broker or brokers who are responsible for taking these ideas and finding an application for them within the context of the organization, and an "energizer," often a leader who has the vision, energy, and enthusiasm to carry the ideas over time from the development stage to the implementation stage.

SNA Method

In this section, I provide an overview of some common SNA metrics and how they can be used to understand knowledge requirements. For a more comprehensive and detailed look at the SNA assessment process and metrics associated with this process, see Hatala (2006). SNA allows us to analyze the relationships among actors in a network (refer to Figure 1). These actors, often referred to as "nodes," can be people, organizations, or IT systems such as databases or applications. Connections among nodes, referred to as "links," indicate

the relationships between actors. Links can contain arrows that indicate the direction of the relationship. For example, in Figure 1, assuming that this is a network of employees and whom they interact with for information, Employee C goes to Employee F for work-related information, but Employee F does not turn to Employee C. Links can be operationalized using a dichotomous scale (e.g., "Do you share information with this person?"; no or yes) or a continuous scale (e.g., "To what extent do you share information with this person?"; 1 = *very infrequently* to 6 = *very frequently*). Where a continuous scale is utilized, it can be dichotomized at a value, which is taken to represent a strong tie (e.g., a link exists if the response is 5 or 6 on a 1 to 6 scale). Typically, network data are dichotomized when the researcher is interested in analyzing a network at a certain cutoff point (e.g., only looking at the network of very frequent information sharers) or the desired SNA metric requires a binary format of the network data (Borgatti et al., 2002; Hatala, 2006).

Two common network types are "bounded" and "ego" or personal networks (Hatala, 2006; Scott, 2000; Wasserman & Faust, 1994). In a bounded network, the nodes (i.e., employees) in the network are predetermined by the business stakeholder and HRD manager because both are needed to target the appropriate individuals or groups for assessment and potential interventions based on the results of the SNA study. Each survey respondent answers the network questions with respect to each employee in the given network. The network questions will differ with respect to the particular HRD problem being analyzed. For example, it could include questions on information sharing, idea generation, problem solving, decision making, friendship, and energizing (Cross & Parker, 2004). Analyzing each network structure can then provide a different perspective of the organization. For example, the information network can be used to analyze employee connectivity, the decision-making network to understand where the power lies in the structure, the idea generation network to understand innovation, and the trust network to gain a sense of the underlying corporate culture. Expressive network structures, such as energizing, sensemaking, and friendship relationships, often provide an effective complement to purely work-related, information-sharing relationships. For each bounded network, different analyses can be performed based on attribute questions asked in the survey. For example, we can look at the information network and show each employee node by work boundary, hierarchical position, job tenure, company tenure, and gender as per the attributes collected in the survey. This allows us to investigate where there might be information silos in the network, such as two divisions not communicating with each other, or the direction of the information flow in the hierarchy chain. For HRD, analyzing network attribute information can point to specific "soft skill" intervention needs of the organization that develop interpersonal competences. Examples of these competences include team building if there is little information sharing within a particular group, diversity training if information sharing occurs mostly within a particular demographic such as gender, and leadership development if communication

is concentrated among only a few people. In addition, "hard skill" training needs can be exposed and targeted to ensure that work performance skills are effectively distributed, nurtured, and placed.

In a personal network analysis, respondents are first asked to list nodes or people pertaining to a name-generator question in the survey. For example, the question might be, "Identify the top 10 people you turn to when trying to solve a critical problem at work." Respondents then answer specific questions regarding each person listed, such as hierarchical level relative to their own functional area in the organization, physical proximity, and primary benefit of the relationship. It is then possible to develop a personal network profile for each respondent to determine how their social networks can be improved (e.g., all people listed in a respondent's personal network are in the same department, which could result in insular thinking) to facilitate learning, improve performance, and improve knowledge sharing.

Metrics to Provide Information on Overall Network Connectivity

This section describes a number of network metrics or indices (summarized in Table 1) that are useful in analyzing overall network structures and people's positions in the network. This list is not exhaustive as only those metrics that are used in the research referred to in this article and that can inform us on KM efforts are highlighted. In addition, these metrics offer key information to HRD practitioners who are responsible for KM or related domains consisting of effective distribution and creation of knowledge in organizations or communities.

Degree centrality refers to the number of links going into (referred to as "in-degree") or coming out of (referred to as "out-degree") a node in a network (Freeman, 1979). Referring to Figure 1, we can see that Employee D is very central in the network, with an in-degree score of 5 and an out-degree score of 4. Centrality measures are very useful in the context of KM practices, as they directly pertain to a person's position in the network. A central person in the information network (i.e., high in-degree centrality scores) can be an asset to the organization as he or she can distribute expertise, experiences, and institutional memory to others; can act as a mentor to newcomers; and can be regarded as a go-to person in times of crisis. However, it is important to identify these individuals as they may also act as bottlenecks for information flow and can potentially be overburdened from information requests (Cross & Prusak, 2002). Centrality measures also allow managers to identify people on the periphery of the network (i.e., low in-degree and out-degree scores). Peripheral people need to be identified as they may have valuable knowledge that could be shared if they were better positioned in the network (Parise et al., 2006).

Density and *cohesion* are two network measures that are more descriptive of the entire network rather than individual nodes. Density in the information network is defined as the ratio of existing information ties in a network to the

TABLE 1:   Select SNA Metrics Relevant to HRD

Type	Description	Implications for HRD
Degree centrality	The number of links going into (referred to as "in-degree") or coming out of (referred to as "out-degree") a node in a network	Identifies central or critical people in the knowledge flow of the organization Interventions can: Decrease information bottlenecks Distribute information more effectively, especially to people on the periphery of the network Ensure succession and continuation of relevant expertise
Density	The ratio of the number of actual information ties in a network to the maximum number of ties possible	Identifies the degree of collaborative knowledge sharing Interventions can: Develop skills to enhance interpersonal effectiveness Decrease cultural or structural barriers to collaboration Target appropriate groups to ensure sufficient level of density to accomplish work tasks
Cohesion	The distance, or the number of links, to reach nodes in a network	Identifies how well distributed knowledge is an organization Interventions can: Shorten the distance it takes for knowledge to reach the entire network Identify leverage points in the network to improve connectivity Decrease redundancies
E-I index	A ratio of the external and internal links for particular subgroups in the network	Determines if knowledge is insular or being shared across subgroups Interventions can: Assign brokers to ensure connections between subgroups Ensure knowledge connections are sufficient both within and between subgroups
Ego brokerage	Measures the degree of brokerage that is occurring, for different network configurations	Determines if knowledge is being disseminated in a specific manner or configuration Interventions can: Assign different brokers based on the desired network configuration Determine who the current brokers are now, which can influence interventions

maximum number of ties possible if everyone in the group shared information with everyone else (Wasserman & Faust, 1994). Network density ranges between 0% and 100%. Common density values in the networks studied by the research team ranged from 5% to 30% for frequent or very frequent information sharing, and this number varied based on the intent and size of the network. Although there is no single measure of goodness, density measures of at least 15% to 20% are found to be associated with effective information sharing in roughly 100-person networks in the research utilized for illustration in this article.

The cohesion metric measures the distance, or the number of links, to reach nodes in a network (Burt, 1976; Doreian, 1974). In Figure 1, the cohesion or distance between Employee D in Division 1 and Employee H in Division 2 is 3. The average cohesion measure for the entire network can be calculated. Generally, for an information network, the lower the cohesion number, the better, because this indicates that there is a shorter distance for knowledge to travel to be disseminated to everyone in the network. Most organizations studied by the research team strive for an average cohesion number of 2. That is, on average, there are two links for any person to reach any other person in the network.

Metrics to Provide Insight on Network Fragmentation and Connectivity Across Subgroups

SNA techniques are also useful to uncover fragmentations or silos that may exist in the company as a result of physical boundaries (e.g., different geographic locations and closed workspace designs) and organizational boundaries (e.g., rigid hierarchical levels, functions and divisions, and different expertise domains). A challenge faced by companies is that even though there may be sufficient knowledge sharing within each subgroup, such as a particular team, department, or division, there may not be sufficient integration among subgroups where interdependencies do exist and collaboration is needed. For example, in Figure 1, although collaboration exists within each division, there is very little information sharing between Divisions 1 and 2.

Understanding the connectivity among subgroups is particularly relevant when it involves different knowledge types (e.g., tacit and explicit) and knowledge tasks (e.g., search and transfer). Hansen (1999), for example, found that strong or direct ties between business unit subgroups facilitated the *transfer* of complex, *tacit* knowledge, whereas weak or indirect ties between business units helped with the *search* of *explicit*, less complex knowledge. A lack of direct ties between business units slowed down the completion time of projects involving the transfer of complex knowledge. Understanding the degree of between-group connectivity (along with the nature of the work task) thus informs the design of effective and efficient work practices.

There are several techniques and metrics that are helpful in identifying within and between subgroup connectivity. The E-I index (external–internal index) looks
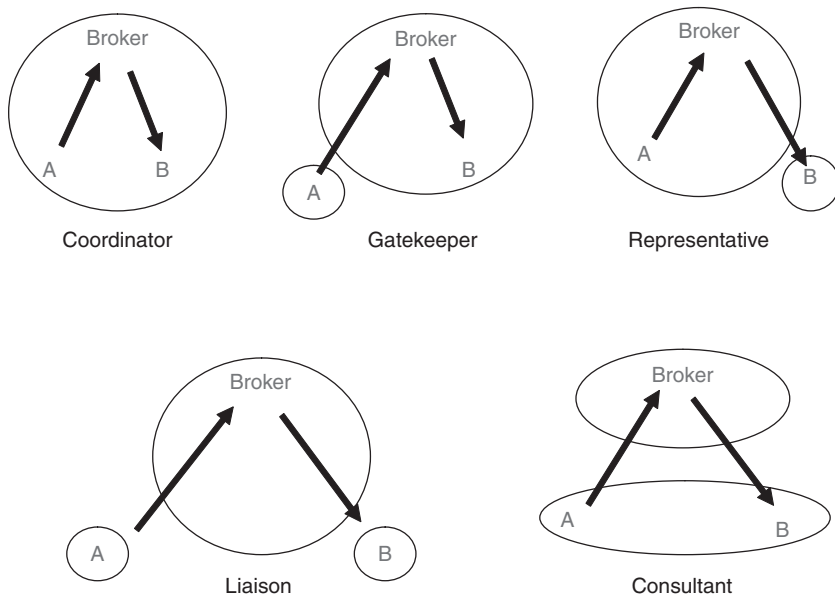
FIGURE 2:   Broker Configurations

at the external and internal links for particular subgroups (Krackhardt & Stern, 1988). The index score ranges from –1, which indicates all ties are internal to the subgroup, to +1, which indicates all ties are external to the subgroup. To investigate connectivity within and between divisions in Figure 1, it is evident that the number of internal links within divisions is much higher than the number of external links across divisions. Therefore, the E-I index would be negative.

The term *broker* in the context of SNA is used to describe nodes in the network that connect different subgroups. These individuals are critical in the context of knowledge and information transfer as they often act as a conduit among departments, locations, and hierarchies. Burt (1992) has argued that brokers are essential to have open networks (i.e., connectivity across subgroups) and that these particular individuals have an advantageous position in the network because of their bridging capability. Other researchers have argued that brokers are essential for innovation because they are able to bring in new ideas from different subgroups (Hargadon, 2003). Although there are several techniques to measure brokers, our research team has used ego-brokerage configurations (coordinator, consultant, gatekeeper, representative, and liaison) to measure brokerage scores for a particular node or individual in the network (Borgatti et al., 2002; Gould & Fernandez, 1989). Figure 2 shows the five different brokerage configurations. Assuming an information network, a source node (A) gives information to the broker (Broker), who then gives

information to the destination node (C). The circles in the figure represent different subgroups (e.g., work boundaries, geographical locations, and hierarchical levels). Brokerage scores indicate the number of times in the network a particular brokerage structure (e.g., coordinator) appears for a particular node. The brokerage scores can inform the HRD professional as to who the top brokers are in the current network. This information is useful for prescribing action items such as creating a role for the broker as a liaison between two divisions, for example.

I next provide three cases from the research—each one describing a company context, its KM challenge, and how SNA was utilized to help HRD managers understand the challenges and provide recommendations to the organization. The three examples illuminate the power of SNA to analyze and target effective and efficient HRD interventions.

Case 1: Knowledge Creation and Innovation

Take the context of a commercial products organization, where the rapid and effective design of new and innovative products was the main objective. The company was facing several HRD challenges focused on the development and transfer of new product knowledge among employees: The cycle time from new ideas to finished products was too slow, new product features that were implemented did not generate the customer excitement that the company had anticipated, and there was duplication of product research across several design teams. SNA was conducted across two divisions: research and development (R & D) and business development. The R & D division was responsible for designing and building prototypes and testing product features. The business development division conducted much of the market research, including understanding current and future customer (i.e., commercial market) requirements for its products.

The research team analyzed both information and expressive networks in this study. Because the focus was on innovation, we wanted to investigate the flow of ideas among people and assess if there were any bottlenecks in the decision-making process. Four bounded networks were examined:

1. Information frequency: "Please indicate the extent to which the people listed below provide you with information you use to accomplish your work." A 0 response indicated the respondent did not know the person. A 1 (*very infrequent*) to 6 (*very frequent*) Likert-type scale was used.
2. Idea sharing: "Please indicate the extent to which you turn to each person below when you have a new idea." A 1 (*very infrequent*) to 6 (*very frequent*) Likert-type scale was used.
3. Decision making: "Please indicate the extent to which you turn to each person below for input prior to making a business decision." A 1 (*very infrequent*) to 6 (*very frequent*) Likert-type scale was used.

4. Energizing: "When you interact with each person below, how does it typically affect your energy level?" The following scale was used: 1 = *de-energizing*, 2 = *neutral*, 3 = *energizing*.

The information, idea-sharing, and decision-making networks were dichotomized at responses greater than 4. Therefore, a link is considered present between nodes or people in the network if the response is greater than 4. The energy network was dichotomized at responses equal to 3 so as to represent the network of energizers.

In addition, a personal (or ego) network analysis was conducted, where survey participants were asked, "Identify up to 10 people that are important in terms of providing you with information to do your work or helping you think about complex problems posed by your work." For each person listed, the respondent answered questions regarding the person's organizational boundary, physical proximity, length of time known, frequency and medium of interaction, and relative hierarchical position.

As can be seen in the idea-sharing network (see Figure 3), the network was clearly fragmented between the R & D and business development divisions. Furthermore, within the R & D division, there seemed to be idea sharing within two separate subgroups. The information network showed a very similar pattern of insular information sharing across the divisions. An investigation of the decision-making network revealed that people turned upward in the organization prior to making a decision and that there were a few individuals in both divisions who had very high in-degree centrality. In other words, decision rights seemed to be allocated among only a few employees.

One of the main findings from the network analysis and follow-up interviews was the lack of idea and information sharing between the R & D division and the business development division. This created HRD challenges on many levels, including the development of new expertise at the individual (e.g., engineer) and group (e.g., R & D) levels. By talking only among themselves, R & D engineers and scientists tended to focus only on enhancing previous product ideas and neglected any thinking toward truly unique and innovative products. From the personal network analysis, less than 10% of R & D's personal relationships were outside their immediate divisions. It was clear that R & D was not involving a broad set of people to help bring innovative ideas into the division. Also, R & D was unaware of what was happening in the commercial marketplace. Customer requirements and preferences were quickly changing, but this was oblivious to the engineers. The business development division was mostly responsible for interacting with customers, but these requirements were not effectively communicated to R & D.

The other interesting finding was the appearance of two subgroups within the larger R & D division. After looking at the idea-sharing network with nodes highlighted by work location, it was clear that physical distance had an impact on idea and information exchange. Each subgroup was located on a different floor within the same building. Interviews with key R & D personnel
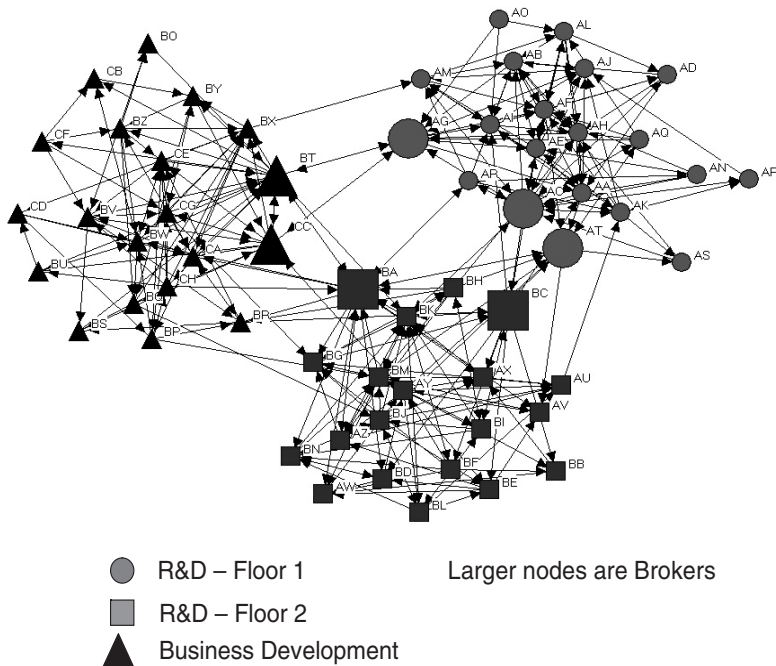
FIGURE 3:   Idea Sharing in a Commercial Products Organization

revealed that even though there was flexibility in terms of what project an employee could work on, most inevitably chose to work with people they had previously worked with and with whom they felt comfortable. These relationships tended to occur on the same floor.

As a result of the network analysis, a series of organization development–type interventions were developed and implemented. The focus of the interventions was to improve communication flow, clarify decision making, and improve R & D's responsiveness to customer requirements.

1. To ensure better idea and information sharing between the business development and R & D divisions, two new job roles were created. Two liaisons were assigned from each division. These liaisons were responsible for both structured interactions (e.g., scheduled meetings to exchange product and market information) and informal interactions (e.g., support any ad hoc information requests between divisions). The liaisons were also responsible for the dissemination of information within their respective divisions. In this way, the organization was assured that customer requirements and opportunities were being relayed to R & D in real

time and that the business development division was aware of new product innovations in the pipeline.

2. To determine the right people to assign as liaisons, a careful analysis of the ego-brokerage scores (as described earlier) was done. Individuals with high liaison scores in the R & D division included BA and AG and in the business development division included BT and CC. Because these employees were in essence already performing the role of a liaison broker, they were considered good candidates to have this formal role going forward. In addition, to ensure that these individuals would inspire and motivate employees among the two divisions, the results of the SNA were utilized to see if these individuals were energizers. These four individuals had very high in-degree scores for the energizing network. Finally, the organization wanted to groom future liaisons, and so they pinpointed employees BX and BG as potential successors. These two individuals, although relatively new to the organization, had some exposure to both the marketing and R & D components of the business and therefore understood both divisions' work processes and cultures.

3. In addition to crafting the new roles described above, further role redefinition was needed. To facilitate better idea sharing within the R & D division and to eliminate the silo that existed between the two subgroups, more frequent cross-project review sessions were held. There was very little fertilization of ideas across projects as most R & D engineers worked with the same people for long periods. The desire was that by making engineers aware of what other project teams were doing, this would help spur new ideas and leverage existing innovations in a new product context. The organization assigned three people within R & D as leaders of these review sessions and contact points for any project related questions. Examining the gatekeeper and liaison broker scores (as described earlier) highlighted that employees AC, AT, and BC had the highest scores. These three individuals were ideal candidates because they communicated with both R & D subgroups and also had high energy in-degree scores. Finally, a designated design room, consisting of workstations, whiteboards, and other equipment that engineers had in their individual offices, was created. The room could simultaneously hold a few project teams. The hope was that by getting engineers to leave their individual offices and work side-by-side in a larger space, this would trigger more communication among engineers, especially those with offices on different floors.

4. The final intervention was the reallocation of decision rights. The decision-making network data were used to identify the employees with the highest in-degree scores within that network (i.e., individuals to whom people turned when decision making). Most of them were senior project managers in the R & D division. The interviews revealed that these individuals were simply overburdened with governance tasks, and this was taking time away from their engineering work. Although certain complex

decisions did require them to be involved, it was the routine decisions around project management that made them feel they were not effectively using their time. As a result, certain operational decisions were reallocated to more junior staff on the project teams.

Case 2: Knowledge Transfer and Retention

A network analysis conducted for a professional services organization focused on one of their largest practices—software services. The practice was distributed across four regions of the U.S. market: northeast, southeast, central, and west. The stakeholder who sponsored this analysis recognized several challenges this particular practice was having. First, there seemed to be very little sharing of project work across regions. Even though a portal was established to capture past project proposals, client information, and market information, it was not frequently used. Second, most project teams turned within their own region for "experts"—partners who had vast experience with a particular software system or knew how to apply a software solution to a particular industry or business context. The northeast and southeast regions were much more established and had higher client loads. As a result, experts within these regions were becoming overextended, whereas experts in the west and central regions were not leveraged. Last, the organization was experiencing a very high attrition rate, in terms of both recent hires and very senior personnel.

The research team wanted to investigate not only the transfer of information among experts but also if this communication led to more client business opportunities. Another objective was to see if experts were aware of the competences of others. The research team looked at three bounded networks, and each of the network's measures were dichotomized at responses greater than 4:

1. Information effectiveness: "Please indicate how effective the people listed below are in terms of providing you with information you use to accomplish your work." A 0 response indicated the respondent did not know the person. A 1 (*very ineffective*) to 6 (*very effective*) Likert-type scale was used.
2. Awareness: "Please indicate the extent to which you are aware of the skills and expertise that each person below possesses." A 1 (*very unaware*) to 6 (*very aware*) Likert-type scale was used.
3. Client opportunity: "Please indicate the extent to which more communication with the person listed below would lead to more client opportunities for you." A 1 (*very unlikely*) to 6 (*very likely*) Likert-type scale was used.

As can be seen in the information network (see Figure 4), the network was clearly fragmented by geographic regions. The E-I index for the network was −0.9 (on a −1 to 1 scale, as described earlier), which means that virtually all links

were within region, not across region. There was effective information sharing within each region, especially within the northeast and southeast regions. For example, the percentage of links that existed (out of all possible links) where southeast consultants indicated they had effective communication with other southeast consultants was 30%. However, when the research team looked at effective communication between different regions, there was a significant drop-off. The percentage of links that existed (out of all possible links) where southeast consultants indicated they had effective communication with west consultants was only 2%. Another key observation was that there were very central people (AA, AU, BP, and CD) in the information network. These were senior partners in the organization. Meanwhile, many of the junior consultants were on the periphery of the network and were not well connected.

The problem with knowledge transfer across regions was partly because of the lack of awareness of consultants' expertise across regions. A study of the awareness network showed that consultants were somewhat aware of the expertise areas of colleagues within their own region (an average of 60% density), but there was very low awareness of expertise across regions (less than 5% density). Finally, in terms of the client opportunity network, the overall density (15%) was higher than that of the information network (10%), which indicated that consultants did see opportunities where further collaboration with others would be helpful. Senior partners did recognize client opportunities from collaborating with other senior partners across regions. Overall, in the client opportunity network, senior partners had the highest in-degree scores, whereas junior consultants had the lowest scores. In other words, employees who took the network assessment considered that the most opportunities resulted from working with senior partners.

As mentioned earlier, the consulting organization was very concerned that knowledge was walking out the door. The network analysis clearly revealed the potential negative impact on the firm if the central senior partners departed. If the senior partners from each region were removed, the density of the overall network would drop from 10% to 5%, and obviously the impacts to within-region connectivity would be great. Also troublesome was what would happen to information transfer across geographies if the top brokers were to leave. If the top broker from each region were to leave the network, then virtually all the links would be internal to the region. In other words, connectivity *across* regions was dependent on only a few brokers, which also posed a risk to the company. Follow-up interviews revealed that these brokers were assistants to the central senior partner in each region, and they did much of the coordination in terms of project planning, budgeting, and prioritization but rarely got involved with individual project teams.

Based on the network analysis results, several actions were taken that spanned the domains of HRD and HRM:
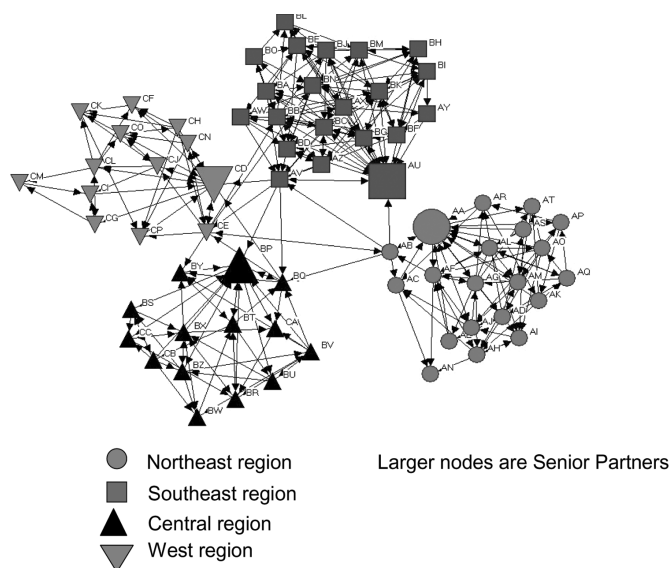
FIGURE 4: Information Exchange in a Professional Services Organization

1. HRM: The stakeholder who sponsored the survey realized that changes
    had to be made to the rewards and incentives scheme to promote knowl-
    edge-sharing behavior. The HRM system actually discouraged collabo-
    rative behavior by measuring consultants' performance solely based on
    partners' and clients' appraisal of their individual contribution to pro-
    jects. Consultants were then ranked against each other to determine their
    overall rating in the organization. To decrease competition, an HRD inter-
    vention to encourage collaboration was created. Specifically, the inter-
    vention involved changes to the performance appraisal system to include
    formal metrics around knowledge sharing and contribution (e.g., the
    extent to which a consultant helped other consultants through sharing
    documents, speaking on client projects' successes and failures, dis-
    cussing client strategies) and metrics that recognize and reward joint
    project work across geographic regions.
2. HRD: HRD interventions to help communication flow were also designed.
    To promote more knowledge transfer across regions, the senior partners
    in each region now periodically meet to discuss current project work and
    potential joint-collaboration efforts. Points of contacts were estab-
    lished in each region to provide real-time help on current projects. For
    example, if a project team in the west region needed expertise on a Java
    application, they could make this request to a contact point in each of the
    regions, who could then locate an expert in his or her region.

3. HRD: Mentoring and socialization interventions were designed. A formal newcomer orientation practice was established for new employees in the organization. During their first year, newcomers were paired with an experienced consultant. The senior consultant was responsible for not only answering any technical or organizational questions but also introducing newcomers to critical people in the organization so that newcomers could quickly build their personal network. During the 6-month and 1-year appraisals, newcomers were asked not only about skills they acquired but also about with whom they had met and started a work relationship. This newcomer orientation practice would help prevent newcomers from being stuck on the periphery of the network, as they are now.

4. HRD: Finally, succession planning was introduced. To reduce the knowledge loss risk posed by the most central people in the network, senior partners were required to groom potential successors. This required the successor to "job shadow" the senior partner, including attending the partner's meetings, understanding the partner's decision-making processes, and being introduced to the partner's key contacts both inside and outside the firm. The firm made sure that the partners had time in their schedules to bring a successor on board.

Case 3: Knowledge Associated With
Job Succession Planning

Let us take the case of an employee (Joe) who transitioned from an engineering position to a leadership position as a product manager. Joe worked in his division for the past 15 years and was promoted several times, eventually to the level of senior engineer. For the past few years, he worked as a project manager on several key initiatives, and his record on these projects made him the ideal candidate to take over as a product manager from the retiring senior manager (Sue). Joe was familiar with the technical aspects of the product, as he had been involved in its original design.

During the period of the research used for illustration in this article, Joe was in his new position for about 4 weeks and was struggling. Although he thought he knew everything about the product and felt he had enough management experience for this leadership role, Joe did not realize the significance of building new relationships so that he could do his job well. An analysis of the current personal network using a Web-based assessment tool developed by the Network Roundtable group was conducted. Joe identified the top 10 people who were important in terms of providing him with information to do his work. Joe also listed the most critical expertise he needed to perform his job well.

Evident from examining his personal network was that Joe was still relying on his network of colleagues from his previous position in the engineering group. Many of his key relationships were with the peers he worked with during the past 10 to 15 years. Joe listed the following six expertise areas as being
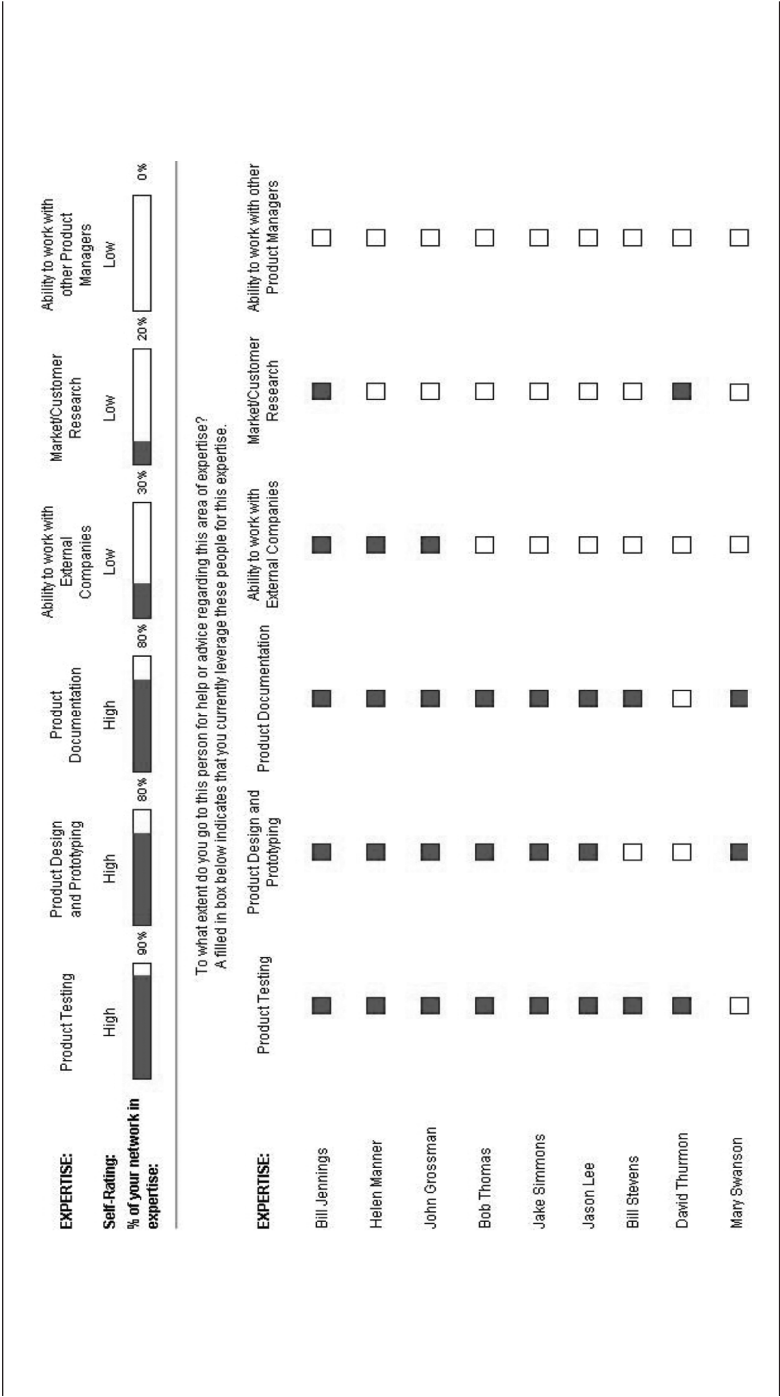
EXPERTISE:

Self-Rating:

% of your network in expertise:

Expertise	Product Testing	Product Design and Prototyping	Product Documentation	Ability to work with External Companies	Market/Customer Research	Ability to work with other Product Managers
Self-Rating	High	High	High	Low	Low	Low
% of network	90%	80%	80%	30%	20%	0%

To what extent do you go to this person for help or advice regarding this area of expertise?
A filled in box below indicates that you currently leverage these people for this expertise.

EXPERTISE:	Product Testing	Product Design and Prototyping	Product Documentation	Ability to work with External Companies	Market/Customer Research	Ability to work with other Product Managers
Bill Jennings	■	■	■	■	■	□
Helen Manner	■	■	■	■	□	□
John Grossman	■	■	■	■	□	□
Bob Thomas	■	■	■	□	□	□
Jake Simmons	■	■	■	□	□	□
Jason Lee	■	■	■	□	□	□
Bill Stevens	■	□	■	□	□	□
David Thurmon	■	□	□	□	■	□
Mary Swanson	□	■	■	□	□	□

FIGURE 5:   Personal Network Expertise Profile

critical to his new job role: market and customer research, product design and prototyping, product testing, product documentation, ability to work with external companies, and ability to work with other product line managers and business development managers. Figure 5 shows the output of Joe's personal network report. It was clear that Joe's current network was redundant in terms of supporting Joe in the technical aspects (e.g., product design, testing, prototyping, documentation) of his new role. His network also provided limited support in the other critical expertise areas, such as market and customer research and working with other product line and business development managers. For example, Joe indicated during interviews that he had very little understanding of the budget process and the competition processes for resources (people and financial) among product lines. He had no one to turn to for advice regarding these issues.

To develop a HRD intervention to help Joe build a more effective network for his personal development, Sue's (Joe's predecessor) personal network was examined. Not surprisingly, Sue had listed similar expertise areas as Joe. The one area that was missing was obtaining executive-level support. Sue understood the importance of gaining the support and sponsorship of key executives, and, more importantly, she knew how to gain that support. Also, the people in Sue's network were all different from those in Joe's network. Sue's key relationships resided in different areas of the organization, and some were also external to the organization. Several of her internal contacts were at a hierarchical level in the organization higher than her level. Before Sue left the company, she was more than happy to introduce Joe to all of her key relationships. In the expertise areas that Joe was lacking, he quickly built relationships with people in Sue's previous network. He took the time he invested in maintaining redundant work relationships and used it to build these new relationships. Joe currently has a vastly different personal network, which is much more aligned with his job needs.

Implications for HRD Research and Practice

As I have argued in this article, it is the informal networks in organizations where much knowledge (both tacit and explicit) creation and transfer takes place. Work rarely gets performed in isolation, and a good understanding of whom people turn to for information, decision making, organizational sense making, and emotional support is needed to develop effective work practices. SNA gives HRD practitioners the diagnostic tools and information needed to ensure that interventions are on target, effective, and efficient.

A future potential SNA application for HRD professionals is to help with the implementation and evaluation of change initiatives (Hatala, 2006). Change initiatives may include internal restructurings, leadership transitions, mergers and acquisitions, or any major program intended to have organizational impact, such as a company-wide mandate to be more innovative. By including the critical individuals and groups involved with the change program in a network assessment, SNA can be used as a tool to analyze and evaluate the initiative.

Taking the case of a merger between two companies, where one of the main merger objectives is the sharing and leveraging of each other's technical expertise, SNA can be conducted to see if in fact there are relationships forming between the two businesses. Conducting SNA assessments over time can help determine if specific interventions (e.g., change incentives, appointment of individuals in particular roles) are effective by comparing and analyzing changes to the structure of the before and after networks. Again, a specific intervention after the merger could be to have periodic meetings (alternating at different physical sites) with large groups of employees from each business for the purpose of getting to know each other, what projects exist, who knows what, and so on. An SNA assessment conducted 6 to 12 months after the merger could help determine if these site visits were helpful in building awareness and relationships between the businesses (especially if compared with the results of an initial SNA assessment conducted right after the merger, before the site visits). Finally, HRD practitioners could use network analysis to help with the implementation of the change initiative by working through change "carriers" (or champions). By identifying key individuals—those whom people go to for expertise, ideas, and problem solving or those who play a brokering role across critical groups—HRD professionals can leverage them to help sponsor, promote, and implement the change program. In the merger example, HRD professionals could work with central technical leaders from both businesses to ensure that they are involved in promoting site visits as an opportunity to meet and eventually collaborate with new colleagues.

Based on the many SNA research projects conducted at Network Roundtable and Working Knowledge, organizations that successfully performed SNA and devised and implemented successful interventions from it tended to have a partnership among the business stakeholder, the KM manager, and the HRD manager. All three stakeholders need to be involved so that the drivers or opportunities for doing SNA are identified. A typical scenario is one where the business stakeholder identifies a driver for doing the analysis (e.g., the perception that business groups should be sharing knowledge). However, based on this SNA research program, it is increasingly the case that the KM and HRD groups advocate the use of network analysis techniques for the purposes of leadership training, succession planning, coaching, mentoring, and personal development interventions. The interpretation of the SNA results also requires that all three groups work together. The SNA metrics by themselves do not necessarily provide a measure of goodness without a business context (e.g., it might not be necessary for two subgroups to share knowledge), but together they provide a valuable lens for understanding KM issues. Finally, as seen in the cases, many of the action items or interventions coming out of a network analysis influence the decisions surrounding HRD options to promote knowledge sharing.

Future research could take a more fine-grained look at the relationship between KM (i.e., knowledge creation, transfer, and retention) and network structure. Relationships or connections between individuals can be operationalized by

specific dimensions of knowledge (e.g., tacit or explicit, timeliness, relevancy, content) as opposed to the simpler dichotomization based on if employees share "knowledge" to help them with their work. Researchers can also investigate different work settings to determine any patterns of network structures. For example, in a work setting where innovation is the prime objective, researchers can study if there are different or optimal network configurations that occur across a set of research sites (given organizational and group characteristics). Although this research stream takes the position that structure shapes actions relevant to KM, it may be possible to integrate mixed or qualitative research methods with SNA tools to expose hidden connections between knowledge creation and sharing and the structure of informal social relationships in organizations.

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