
Social Network Analysis in Human Resource Development: A New Methodology

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Through an exhaustive review of the literature, this article looks at the applicability of social network analysis (SNA) in the field of human-resource development. The literature review revealed that a number of disciplines have adopted this unique methodology, which has assisted in the development of theory. SNA is a methodology for examining the structure among actors, groups, and organizations and aides in explaining variations in beliefs, behaviors, and outcomes. The article is divided into three main sections: social network theory and analysis, the social network approach and application to HRD. First, the article provides an overview of social network theory and SNA. Second, the process for conducting an SNA is described and third, the application of SNA to the field of HRD is presented. It is proposed that SNA can improve the empirical rigor of HRD theory building in such areas as organizational development, organizational learning, leadership development, organizational change, and training and development.

Keywords: *Social Network Analysis; social capital; HRD; Methodology; theory*

The field of human resource development (HRD) has slowly shifted its focus from the individual to a greater consideration of multiple levels: individual, group, work process, and organization (Swanson & Holton, 1997). Whether dealing with an individual, group, or the organization as a whole, an HRD practitioner's aim is to work toward increasing organizational effectiveness through the use of learning and performance improvement methods. Individual behavior is a reflection of the environment and specific behavioral responses cannot accurately be predicted without knowledge of the context in which the individual or group functions. It is therefore important to understand the interpersonal relationships that occur in an organization and the impact contextual factors have on the individual's response to the work environment. Creating a balance between interpersonal dynamics and the working environment is critical to organizational

effectiveness (Cohen, 1990; Sambrook, 2005; Yamnil & McLean, 2001). However, HRD methods in which practitioners can analyze the interaction between individuals and their environment have not been readily available.

HRD scholars need to become aware of as many tools as possible to further explore processes in which organizations become more effective. Because HRD is relatively young as a scholarly discipline, it is imperative that its foundation be built on strong theoretical underpinnings. A proposed theoretical foundation of HRD by Swanson (1998) consists of economic, psychological, and system theory within an ethical framework. However, working from only one theory will not suffice in the development of HRD; more of an integrated approach is required to fulfill its purposes (Swanson, 1998). Swanson goes on to state:

The journey to this integrative state results in the organizing concepts, codified knowledge, underpinning theories, particular methodologies, and the unique technical jargon of HRD. (p. 94)

For HRD practitioners and researchers to improve the interactivity between individuals that leads to increased performance and effectiveness, it is necessary to identify techniques that measure the relations between people within a given environment. Social network theory involves a body of methods, measurement concepts, and theories that provide an empirical measure of social structure. A more comprehensive coverage of these topics can be found from sources such as Freeman, White, and Romney (1989); Scott (1996, 2000); and Wasserman and Faust (1994) who discuss social network theory, the utility of social network analysis, and the process and method for conducting social network analysis. Social network analysis (SNA), which is the main methodological procedure for developing network theory, holds promise for providing HRD researchers with a tool to study the dynamics between individuals and the forces that impact relations between them. SNA promises to add significantly to theory building in the field of HRD by providing a methodological approach for improving the empirical rigor of conducting quantitative research in such areas as organizational development, organizational learning, leadership development, organizational change, training, and development. This article will add to our knowledge by reviewing specific features of SNA and applying them to an HRD context, which is not available in the sources cited above.

With new computer technology emerging in the past couple of years, SNA has made considerable strides in allowing researchers to conduct their own analysis from the comfort of their computers. As a result, SNA has branched out from its origins in sociology and now is commonly used in diverse fields such as management (Borgatti & Cross, 2003; Cross, Parker, Prusak, & Borgatti, 2001; Sparrowe, Liden, Wayne, & Kraimer, 2001; Tichy, Tushman, & Fombrun, 1979), anthropology (Avenarius, 2002; Goodreau, Goicochea, & Sanchez, 2005; Hage & Harary, 1983; Johnson, 1994; Sanjek, 1974), political science (Bae & Choi, 2000; Brandes, Raab, & Wagner,

TABLE I: Topics Studied with Social Network Analysis and Researchers

<i>Topic</i>	<i>Researcher</i>
Occupational mobility	Breiger, 1981, 1990
Performance	Sparrowe, Liden, Wayne, & Kraimer, 2001; Doving & Elstad, 2003
Social support	Gottlieb, 1981; Lin, Woelfel, & Light, 1986; Kadushin, 1966
Group problem solving	Bavelas, 1950; Bavelas & Barret, 1951; Leavitt, 1951
Diffusion and adoption of innovations	Coleman, Katz, & Menzel, 1957; Agapitova, 2003; Hargadon, 2005
Corporate interlocking	Levine, 1972; Mintz & Schwartz, 1981a, 1981b; Mizruchi & Schwartz, 1987
Collaboration	Cross, Borgatti, & Parker, 2002; Joshi, Labianca, & Caligiuri, 2002; Parker, Cross, & Walsh, 2001.
Learning	Borgatti & Cross, 2003; Cross, Parker, Prusak, & Borgatti, 2001; Reffay & Chanier, 2000
Exchange and power	Cook & Emerson, 1978; Cook, Emerson, Gillmore, & Toshio, 1983; Cook, 1987; Markovsky, Willer, & Patton, 1988
Consensus and social influence	Friedkin, 1986; Friedkin & Cook, 1990; Doreian, 1981; Marsden, 1990

SOURCE: Adapted from Wasserman and Faust (1994).

2001; Kinsell, 2004; Knoke, 1990; March, 1955), and psychology (Callan, 1993; Gottlieb, 1981; Koehly & Shivy, 1998; Rapoport, 1963; Seidman, 1985; Toshio & Cook, 1993) to name a few. For further examples of topics that have been studied using SNA, refer to Table 1, Topics studied with Social Network Analysis and Researchers.

The purpose of this article is to add to HRD's integrated approach to applying theory by introducing SNA. SNA is a methodology for examining the structure among actors, groups, and organizations that works to explain the variations in beliefs, behaviors, and outcomes. Drawing on literature from several fields of study presently utilizing SNA (i.e., psychology, management), the applicability for the HRD practitioner and researcher is illustrated. The literature review has provided insight into the universality of SNA and its potential usefulness to HRD. Therefore, the focus of this article is the methodological process involved in SNA and its applicability to HRD. The article was divided into three main sections: a brief overview of social network theory and analysis, the social network approach, and application to HRD. First, the article provides a brief overview of social network theory and the utility of social network analysis. Second, the process for conducting a SNA is reviewed, and third, the application of social network theory to the field of HRD is discussed.

Method

A literature review of social network analysis was conducted through a search from the ACM Digital Library, EBSCO Host's Academic Search Primer, Business Source Primer, ERIC, Proquest, PsychInfo, and Social Index databases. The key words used in the literature search included: social network theory, social network analysis, social capital, and HRD. Focus was particularly placed on exploring the following questions.

1. Where does social network theory originate from?
2. What disciplines have adopted SNA as a research method for theory building?
3. What are the primary SNA resources that serve the network community?
4. What research directions and implications for the field of HRD can be drawn from the literature?

As a result, four bodies of literature were reviewed: sociology, anthropology, psychology, and political science. The sociological literature was used as the foundation for social network theory and addressed Question 1, while anthropology, psychology, and political science literature were drawn upon as examples of fields that had adopted SNA for research purposes addressing Question 2. The focus of the literature review was intended to identify fields that had adopted SNA as one of their research methods. In addition, two primary SNA resources, well known to the network community, Scott (2000) and Wasserman and Faust (1994), were used as the principle references for the technical aspects of the article (Question 3).

The SNA concepts utilized for this article were identified through technical reference manuals and SNA resources found in academic books and journals. The SNA process identified in the section "The Process for Conducting a SNA" was adapted by Scott (2000) and Wasserman and Faust (1994). A number of resources throughout the article are highlighted. Implications for HRD are generated from this research addressing Question 4.

Social Network Theory and Analysis

The origins of social network theory began in the early 1930s within three different distinct groups (psychology, anthropology, and mathematics). Most notably, Moreno (1934) created sociograms, which basically represented the mapping of relationships between individuals by displaying points connected by lines (geometry of interpersonal relationships). Sociograms were produced to help identify group leaders, isolates, directional ties, and reciprocity in friendship circles. This new approach was formalized by Cartwright and Harrary (1956) using graph theory as the mathematical measurement of the relationships between points and lines. The original symbols used to describe groups of people as collections of points were as follows: "signed" (+ means "likes" and—means "dislikes"), "directed"

(arrow from Person A to Person B and vice-versa), and “ties” (lines), which form a network structure. A further historical description can be found in Scott’s (2000) *Social Network Analysis: A Handbook*, chapter 2.

According to White (1997), network theory is formal theory that possesses many substantive theoretical applications. White goes on to state the following:

First, there are many problems across different disciplines that may benefit from the use of similar formal concepts to understand their “network” (linkage and context) component, although substantive interpretations will vary as to the role played by a given formal concept in differing phenomena. Second, to the extent that similarly defined concepts are mobilized in “puzzle solving” in different disciplines and problem areas, we can pose comparative questions not just between different cases of the same phenomenon but between different phenomena, where we can ask whether or how some of the same types of processes may be operative.

Network theories of social structure are not only concerned with quantitative studies of social networks but the process in which theory is established and the identification of linkage and context effects. A number of theories have been introduced through the network perspective. The most popular linkage to social network theory is the notion of social capital. Coleman (1988, p. 16) states that “unlike other forms of capital, social capital inheres in the structure of relations between actors and among actors. It is lodged neither in the actors themselves or in physical implements of production.” Many approaches have been made to conceptualize social capital. The most notable of these are weak-tie theory (Granovetter, 1973), structural hole theory (Burt, 1992), and social-resources theory (e.g., Lin, Ensel, & Vaughn, 1981a, 1981b). Weak-tie theory focused on the characteristics of the tie between actors (strength of ties); structural hole theory emphasized the bridging properties between individual groups or networks; and social-resources theory focused on the characteristics of the contacts within the network versus the nature of the tie or the pattern of ties among contacts. Although each of these three approaches to the conceptualization of social capital differs and the latter two supersede the earlier, they all follow the convention of SNA.

SNA employs a unique measurement approach, which is quite distinctive from other perspectives, by utilizing structural or relational information to study or test theories (Wasserman & Faust, 1994). The SNA approach provides formal definitions of the structural elements that exist within networks (i.e., actors, subgroup of actors, or groups). Wasserman and Faust (1994, p. 21) state “these methods translate core concepts in social and behavioral theories into formal definitions expressed in relational terms.” They go on to explain that all of these concepts are quantified by considering the relations measured among the actors (Wasserman & Faust, 1994). This unique approach provides insight into the dynamics of the interaction between actors and the formation of observable patterns of information exchange between network members. The ability to measure relationships

helps define the behaviors that exist and the impact they might have on the capability of an individual to function among others.

SNA is utilized for descriptive studies grounded in theoretical questions and assumptions and can serve as a method for identifying how change operates and the forces that cause certain effects (Feld, 1997; Wellman, Wong, Tindall, & Nazer, 1997). SNA is a general set of procedures that uses indices of relatedness among individuals, which produces representations of the social structures and social positions that are inherent in dyads and groups. These representations are important for describing the nature of the environment and the impact it has on the individuals who form the relationships. A social network is a set of people or groups of people, "actors" (in the jargon of the field), with some pattern of interaction or "ties" between them. These patterns can typically be represented as graphs or diagrams illustrating the dynamics of the various connections and relationships within a group. The best way to understand the multifaceted networks that occur in today's society is by providing a visualization of the network structures themselves. However, the need to control the location of errors, which may result from such simplifications, is paramount. Strategies for alleviating this concern include choosing simple, geometric shapes as *a priori* constraints to limit the permissible spatial locations of network nodes (Krempel, 1994). These shapes help to illustrate the differences between nodes and their level of connection to the entire network.

According to Wasserman and Faust (1994), there are some basic assumptions to the network perspective. They include the following: (a) actors and their actions are viewed as interdependent rather than independent, autonomous units; (b) relational ties (linkages) between actors are channels for transfer or "flow" of resources (either material or nonmaterial); (c) network models focus on how individuals view the structural environment of a network as providing opportunities for or constraints on individual action; and, (d) network models conceptualize structure (social, economic, political, and so forth) as lasting patterns of relations among actors. The main focus of SNA remains on the interactional component. Attribute data can be collected as well, such as age, gender, and race and can provide profiles of network members.

The Social Network Approach

Once the researcher has established the research questions, the process to conduct a social network analysis may involve the following steps: (a) determining the type of analysis; (b) defining the relationships in the network using a theoretically relevant measure; (c) collecting the network data; (d) measuring the relations; (e) determining whether to include actor attribute information; (f) analyzing the network data; (g) creating descriptive indices; and (h) presenting the network data. These steps were identified

and adapted from Scott (2000) and Wasserman and Faust (1994), as well as the author's experience in conducting SNAs. These two sources are the most widely referenced sources of SNA methodology in all of the network literature. Each of these eight steps for conducting social network analysis is briefly described in the following sections.

Determining the Type of Analysis

The first step for conducting an SNA is to determine what form of analysis will take place. There are two basic forms of analysis to a SNA—*ego network analysis* and *complete network analysis*. *Ego network analysis* includes the relationships that exist from the point of a particular individual and can be determined through the use of a traditional survey. The surveys are geared to elicit information about the people they interact with, and about the relationships among those people. No attempt is made to link up the individuals as the respondents were part of the random sample and the likelihood of individuals knowing anyone else is low. The ego network analysis allows the researcher to assess the quality of the individual's network, such as size and diversity, or the ability to relate the attributes of ego with the attributes of alters. For example, an analysis may be conducted on individuals within an organization to determine who belongs to the employee's network. The number of ties is limitless and the network itself may include a large number of outside contacts especially if the individual is new to the organization. Analyzing this type of network may be useful for knowledge-intensive organizations, such as in engineering, consulting, and medicine, where new and relevant information is critical to high performance.

Complete network analysis is an attempt to obtain all the relationships among a set of respondents. An example of a complete network analysis would be a department within an organization. If you wanted to know how new product information flows between sales representatives, the members of the network would include all the sales representatives, sales managers, the customer service department, and so on. This approach would help determine which individuals are sought out for new product information and those who are seeking the information.

SNA involves three basic units of analysis—*dyadic* (tie-level), *monadic* (actor-level), and *network* (group-level). *Dyadic* is basically raw data and each case is represented as pairs of actors. The variables are attributes of the relationship among the pairs (e.g., strength of friendship; provides advice or not) and are an actor-by-actor matrix of values involving one for each pair. For example, if the goal is to measure the frequency of time spent obtaining assistance from an individual, the value of that relationship can be rated (i.e., 1 = *never* to 5 = *everyday*) based on the time spent seeking assistance from the person. *Monadic* involves cases of actors, with the variables being

aggregation that count the number of ties a node has or the sum of distances to others. For example, when looking for “opinion leaders,” the goal would be to locate someone who is central to the network (centrality measure). Finally, the *network* unit of analysis involves cases of whole groups of actors along with the ties that exist among them. Variable aggregations count such things as number of ties in the network, average distance, extent of centralization, and average centrality with each variable having one value per network. For example, a researcher may want to measure the number of connections that exist within a particular group (i.e., density) to determine the communication flow with the network. All of these units of analysis are determined at the onset of the analysis.

Defining the Relationships within the Network

Once the researcher has identified the type of network analysis to be conducted, the second step is to determine how the relationships will be defined. Several different relations can be measured on the same group of individuals. Deciding which relations to measure is determined by the theoretical underpinnings of the research itself. Examples of the types of relations that can be measured might include communication relations (e.g., who speaks to whom); instrumental relations (e.g., who asks whom for help); power relations (e.g., who follows whom in informal groups); and interpersonal relations (e.g., who likes who). The researcher may be interested in determining which relationships reveal information-sharing potential, rigidity in the network, or well-being and supportiveness in the network (Cross & Parker, 2004). Each of these examples represents the types of relationships that may be explored in order to determine the overall structure of the network. In addition to examining the dynamics of individuals within a group, defining the relationships that exist will encourage the exploration of the structure of the network and how individuals work together to achieve optimal performance.

In the case of HRD, network actors could consist of key stakeholders, individual organizational members, partnerships, customers, temporary workers, contractors, and other organizations. The HRD researcher or practitioner may be interested in the relational patterns of frontline workers and their interaction with each other, organizational decision-making influences, communication flow between managers and their workers, diffusing change within the organization or the identification of “opinion leaders.” Identifying these relational patterns will assist in the development of training initiatives and employees to meet the needs of both the organization and the individuals.

Collecting Network Data

The third step is to determine how the network data will be collected and measured. The process of measuring the relationship is actually guided through the questions presented in the research. For example, if a researcher is trying to determine which individuals are sought out for help within an organization, the technique chosen to gather the data will be based on a number of different factors. Some of these factors include access to the network members, availability of members, timeline for the analysis, and access to historical documents. Once these factors are dealt with, employing the appropriate data collection technique, such as observation, interviews, surveys or archival documents, can be used to determine the existing relationships among network members (Scott, 2000).

Measuring the Relationships

The fourth step is to determine how the relationships within the network will be measured. Network relations can be measured either as binary or valued. Binary measures are simply indicated by a 0 or 1. The lack of a relationship between two actors is represented as a “0,” while a “1” indicates the presence of a relationship. If a researcher was trying to identify who knows whom in a large organization, they may simply want to determine if an individual is known by others. However, if the researcher wants to examine the strength of the relationship, a valued measure would help determine the extent to which individuals interact with one another. Using a Likert-type scale would allow the respondents to rate their interaction with other people. For example, if the researcher wanted to find out who supplied the company gossip, they could ask the participants to rate their relationship with others on a scale of 1 to 5. Those individuals that received a number of 5's could be deemed a source for company gossip. In addition, looking at the direction of the relationship can further strengthen the data. Is the individual who is seeking information also being solicited in return? This can provide valuable insight into whether communication flow is directional when trying to identify subject matter experts.

Including Actor Attribute Information in the Analysis

In addition to collecting relational data, the fifth step may involve the collection of attribute characteristics from actors to help determine unique similarities in groups of individuals. For example, it is important to understand with whom a new employee is conversing in order to predict future performance. Identifying the relational ties with the profiles of the individuals will

help to establish similarities in work habits and opportunities for success (Brass & Labianca, 1999). Attributes such as age, ethnicity, religion, and performance record are just a few of the variables that require consideration when conducting a network analysis regarding future performance. If the researcher can identify with who the new employee is frequently communicating, they may be able to determine the performance direction of that individual based on the profiles of their main contacts. If the performance levels of the contact are in keeping with the organization's standards, the supervisor may encourage the employee to continue communicating with these individuals. If the profiles are negative, the supervisor may wish to intervene and direct the new employee toward higher performing employees. It is important to keep in mind that the research question will determine which attribute characteristics are required.

Analyzing the Network Data

The sixth step involves the analysis of the network data. There are many computer packages that provide the ability to perform an SNA. Most notably, UCINET 6 offers the researcher the ability to compute network measures (Borgatti, Everett, & Freeman, 2002) as well as to generate sociograms through its incorporated visualization software NetDraw (Borgatti, 2002), which is included with the package. The mathematical procedures involved in SNA are derived from graph theory. In analyzing a social network, structural indices are used to describe the overall connectivity of a network. Within the SNA framework there are a number of graph structures that should be presented. First, the nodal degree represents the number of ties between other nodes or actors. For nondirectional ties, the number of connections to a particular node is calculated as either present (1) or not present (0). For directional ties, the strength of the connection is based on the value associated with the ranking of the relationship (i.e., 5 = I speak with this individual everyday). This allows the researcher to see how often the actor seeks out other individuals (out degree) and how often they are sought by others (in degree). Identifying the out degrees and in degrees of a network forms an index relating to the ability of the individual to contact others and their popularity within the group.

The path in a relationship represents links between nodes. As with nodes, these paths involve a number of different characteristics. The characteristics of these paths should be defined in the same way as the node through the research questions. An important consideration for the researcher is to realize that these paths may not be connected in the same way. One actor may consider a relationship to be very close; however, the feelings of the other actor in the same network may not be the same. These relationships are then considered to be bidirectional. Within the HRD field, these relationships

may involve the flow of information for subject matter experts (SME). Although an individual has been identified as an SME, that does not mean that other individuals are seeking out their advice. This can be identified through an SNA, which may demonstrate that the SME is contacting others, but only a select few are getting in contact with the SME. The researcher may only want to establish that a relationship exists (binary). For example, all other employees in the organization know the SME. However, the researcher may want to identify the strength of the relationship between the SME and other employees at which time they may define the path as a value (i.e., 5 point Likert-type scale). The researcher then has the option of identifying the high valued paths connected to the SME, which will determine if the right relationships are being developed. On the other hand, the researcher might want to identify the low value paths to the SME in order to implement an intervention to increase connectivity between the SME and employees.

Creating Descriptive Indices of Social Structure

Once the data have been input into the researcher's software of choice, the seventh step involves the type of measures to be utilized. Some of the formal theoretical properties in the network perspective include centrality (betweenness, closeness, and degree), position (structural), strength of ties (strong/weak, weighted/discrete), cohesion (groups, cliques), and division (structural holes, partition). These represent the building blocks for developing and conceptualizing network theory (White, 1997). The uniqueness of SNA allows for the identification of the relationships among a group of individuals rather than looking at these relationships independently and separately from the social context. HRD researchers can use SNA to determine how the relationships will affect the individuals themselves. However, to examine these relationships, the social structure must first be described. There are various measures in SNA that produce discrete indices for describing the structure of a given network. These unique measures are the basis for understanding the relationships that exist within a group and the impact they may have on the individual and the network as a whole. A description of the measures follows.

Centrality. Centrality refers to the position of a node within a particular network. Two measures of centrality must be considered during the analysis: local centrality and global centrality. Local centrality deals with the number of direct ties with all the nodes in the network. A high local centrality number represents a more centralized location of the node. These nodes can help facilitate the flow of information from one group to the next within an organizational context. Without these nodes, structural holes would be present. Consequently, it would be difficult for information to flow freely from one group to another unless it

goes through the individual connecting the groups. For obvious reasons, the individual bridging these gaps is in a position of power and can control what information goes to whom (Burt, 1992, 1997).

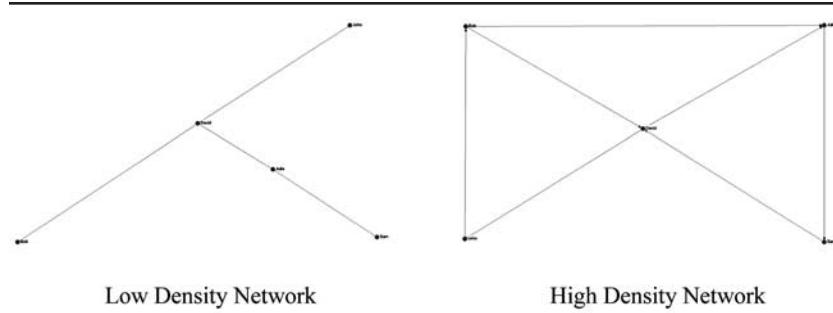
Global centrality is calculated by adding up all the paths from a specific node to all other nodes in the network. If a node is connected via another node, two paths will be added to the overall calculation of global centrality. Calculating global centrality may be more useful for those nodes that are not highly connected but provide links from one set of nodes to the other.

Another way of measuring centrality is to determine the “betweenness” of nodes. This refers to a particular node that lies “between” the other nodes in the network. A node with a relatively low degree of betweenness may play an important intermediary role and as a result will be very central to the network (Scott, 2000). For example, a division within an organization, which has high betweenness, is vulnerable to information flow disruption if someone were to leave. Therefore, it is important to identify these actors in order to administer the appropriate intervention. A possible intervention could include the creation of monthly meetings that allow all members of both divisions to share information. This formal process will ensure that information is shared between members and continues to flow between divisions.

Density. Density is a measure of the level of connectivity within the network. It represents the number of actual links as a proportion to the total possible links that can exist. To calculate the density of a network, the following equation is used:

$$\frac{l}{n(n-1)/2}$$

where l represents the number of lines present and n represents the number of nodes within the network. The value of the density measure can range from 0 to 1, where 1 represents complete density within the network. If, for example, a network has a density measure of .55, the actual number of ties present within the network is 55% of the potential number of possible ties. In most cases, this implies the greater the density, the greater the cohesiveness within the group. However, high levels of density in some situations may impact the ability of the group to perform due to the way information is required to flow through the network. Conversely, low density levels may indicate a poor connectivity between group members and can impact the flow of information required to perform at an acceptable level. Identifying the appropriate density can only be accomplished within a given organization. Determining an appropriate level within a network requires an assessment of the function of the group, and its need to be tightly connected. If it is deemed necessary to have a highly connected group, measuring for density (pre-test) and administering an intervention to deal with in-

**FIGURE 1: ILLUSTRATED NETWORKS**

NOTE: The names used in this example are fictitious.

creased connectivity can be attempted. Once the intervention has been completed, a second measure for density (post-test) can be conducted to determine if there has been any increase in connectivity.

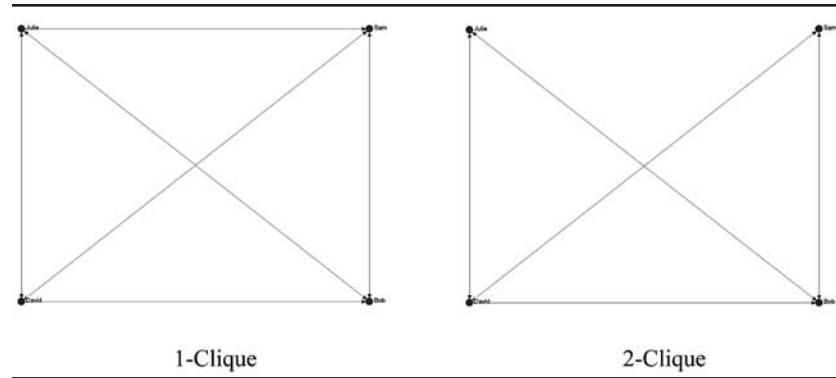
Figure 1 provides an example of density levels within a network. The low density network has a 40% density level and is calculated through the formula:

$$\frac{4}{5(5-1)/2}$$

The high density network in figure 1 has a density of 70% as indicated by the following formula:

$$\frac{7}{5(5-1)/2}$$

Cliques. An important aspect of HRD is the group dynamics that exist within departments and units of an organization (Church & Waclawski, 1999; McClernon & Swanson, 1995). A clique is a subset of nodes that are completely connected and do not appear in any other cliques (Scott, 2000). To determine which cliques exist within a network, the n -clique procedure can be employed. The n -clique procedure allows the researcher to identify cliques within the network by setting their desired level of connectedness between actors. For example, a strong clique may be defined as any node that is 1 degree from another node. Those nodes linked by 1 degree, which are not associated with any other clique, are identified as a strong clique. Therefore, a 1-clique procedure would be conducted to identify those individuals with 1 degree of separation. The researcher may also want to relax the 1-clique criteria and expand it to a 2-clique procedure. This in turn relaxes the criteria of clique members and would therefore identify a group of nodes that are 2 degrees separated while maintaining the 1-clique criteria. The degree of separation represents the strength of the relationships within the clique. In most cases, anything over a 2-clique level

**FIGURE 2: n-Clique of Size 4**

NOTE: The names used in this example are fictitious.

would be considered less reliable as the researcher would have to have a strong understanding of the actors involved. With a 1-clique procedure, there is confidence that the nodes are highly connected; with the 2-clique procedure, the connectedness remains fairly close as only one node separates one actor from another actor. Figure 2 provides an example of 1-clique and 2-clique criteria. If a 1-clique criterion is chosen by the researcher for which the value of n is 4, each of the actors must have a direct connection to each member (1 degree of separation) in order to be identified as a clique. When the 2-clique criterion is chosen, the actors may be linked indirectly through another actor (Sam and Julia are only connected through David and Bob, which is 2 degrees of separation).

Reciprocity. For a group to be fully cohesive, there must be a “give and take” relationship between members. For performance to excel, a level of reciprocity must be instilled in the work place in order to increase the likelihood that organizational members will provide assistance to each other without the fear of not receiving the same in return (Riedl & Van Winden, 2003). Through SNA, the researcher is capable of determining whether the relationships that exist between group members, departments, or divisions possess an exchange of ideas on an ongoing basis. Bidirectional ties between nodes can help identify which individuals are communicating openly with others in the organization. Strategies to encourage this continued communication path could be explored to assist in enhancing the relationships. On the other hand, if ties are not being reciprocated, further investigation may be required to determine the impact. This can be extremely useful to practitioners after having implemented training to a group of individuals.

For more detail on the measures used in social network analysis, please see Wasserman and Faust (1994).

TABLE 2: Valued Data Presented in a Matrix Format (bi-directional)

	<i>Bob</i>	<i>Julie</i>	<i>Sam</i>	<i>David</i>	<i>John</i>	<i>Kim</i>	<i>Ralph</i>	<i>George</i>	<i>Kent</i>	<i>Byron</i>
Bob		1	5	1	2	1	1	2	1	5
Julie	1		4	1	2	2	5	2	1	1
Sam	5	5		1	2	3	1	5	5	4
David	1	4	2		3	5	1	4	1	1
John	2	5	5	2		3	5	5	5	5
Kim	1	1	4	5	2		1	2	1	1
Ralph	5	1	5	5	3	5		5	3	5
George	1	1	3	1	5	1	1		1	1
Kent	1	1	5	1	3	5	1	2		1
Byron	5	1	5	1	5	2	1	2	1	

NOTE: The names used in this example are fictitious.

Presenting the Network Data

The final step involves the presentation of the data. Social network data can be presented in two ways: matrix data and the construction of sociograms. The matrix data will allow the researcher to present the mathematical transformation of the information, whereas the sociogram will provide a visual structural representation of the data. The matrix data is typically more convenient for interpreting the data as it provides all of the relational data between actors in a simple and complete form. Both of these forms are useful in presenting the findings of a network and, in most cases, both are incorporated into an analysis.

Matrix data. Once the data from the analysis have been collected, it can be presented in a matrix format (see Table 2). Table 2 illustrates valued scale responses to a survey question (i.e., who do you go to for help, 1 being *never* and 5 being *daily*). As an example, Bob seeks Sam's help and Sam seeks Bob's help on a daily basis, which is indicated by a 5 in their respective columns (daily basis). Using a matrix will allow the researcher to see all the data at once across the entire population. If the data is unidirectional only the lower portion of the matrix will be used (i.e., if A works with B, then the opposite is always true). If the data is bidirectional then both the lower half and upper half will be displayed in order to see the full relationship (i.e., A seeks out advice from B, but B does not seek out advice from A). It is possible to create matrices with partial data to observe specific groups within the entire network. For example, the researcher may want to look at the strength of ties within a specific division of the organization.

When calculating some of the SNA structural indices it is required that the binary format is utilized to describe relations. For example, if the researcher is using a valued scale to determine the relationship between

TABLE 3: Valued Data Presented From Table 2 After Being Dichotomized

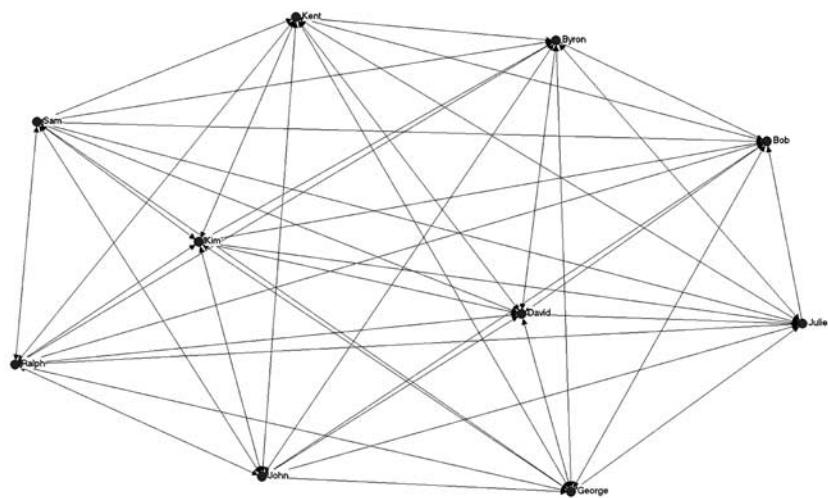
	<i>Bob</i>	<i>Julie</i>	<i>Sam</i>	<i>David</i>	<i>John</i>	<i>Kim</i>	<i>Ralph</i>	<i>George</i>	<i>Kent</i>	<i>Byron</i>
<i>Bob</i>		0	1	0	0	0	0	0	0	1
<i>Julie</i>	0		0	0	0	1	0	0	0	0
<i>Sam</i>	1	1		0	0	0	1	1	1	0
<i>David</i>	0	0	0		0	1	0	0	0	0
<i>John</i>	0	1	1	0		0	1	1	1	1
<i>Kim</i>	0	0	0	1	0		0	0	0	0
<i>Ralph</i>	1	0	1	1	0	1		1	0	1
<i>George</i>	0	0	0	0	1	0	0		0	0
<i>Kent</i>	0	0	1	0	0	1	0	0		0
<i>Byron</i>	1	0	1	0	1	0	0	0	0	

NOTE: The names used in this example are fictitious.

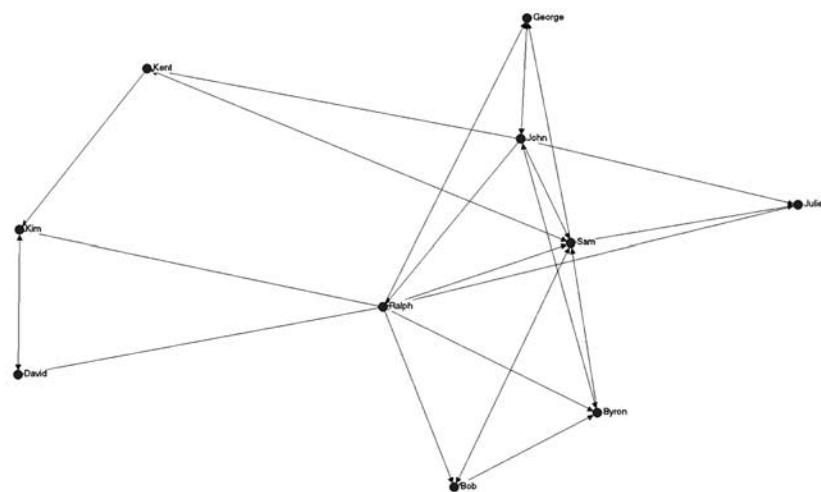
Actor A and Actor B, it becomes necessary to dichotomize the data so it takes on a binary format. Let us suppose that the SNA posed a question regarding how often Actor A seeks out information from Actor B. The scale would typically range from 1 representing *never* to 5 being *everyday*. It might be important to the researcher to determine which employees are being sought after and they would only want to see those that have been identified as a 5. The researcher can then recode the data so that all 5's become a 1 and the values from 1 through 4 are made equivalent to 0 (see Table 3). This is necessary, as most SNA computations require a binary format to compute calculations. However, to account for a wider range of responses, repeating the process so the analysis accounts for a greater representation of responses can be conducted by making 3 to 5 on the scale 1's and 1 to 2 equal to 0.

Sociograms. Sociograms are visual representations of the data matrix. They allow the researcher to map out the relationships that exist and provide a visual identification of structures within the network. However, the larger the network, the more difficult it will be to interpret the sociogram (see Figure 3). We can see from Figure 3 that even a small number of network members can be enormously complex. As in the matrix data format, the researcher may choose to display only the most relevant paths in order to make the sociogram less confusing. If valued data are being collected, the sociogram may display only those values relevant to the research question. For example, the researcher may display only the strong relationships (all the 5's in a 1 to 5 Likert-type scale) regarding the frequency of employee contact in the graph.

Basically, what is presented in the sociogram is simply another way of displaying the same information in the matrix data format. The same data presented in Table 3 are displayed in the sociogram in Figure 4.

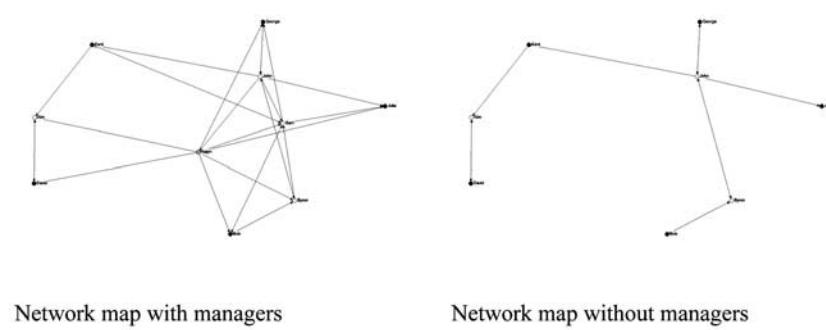
**FIGURE 3: 10 Node Network**

NOTE: The names used in this example are fictitious.

**FIGURE 4: Sociogram Representation of Matrix Data in Table 3**

NOTE: The names used in this example are fictitious.

If there is an absence of a relationship, no line appears or if the relationship is unidirectional the line will have only one arrowhead. As in the matrix data format, the sociogram can be presented to only represent specific attributes. For example, if the SNA is looking at the flow of information

**FIGURE 5: ILLUSTRATED NETWORKS**

NOTE: The names used in this example are fictitious.

between managers and subordinates, the researcher can study two different displays of the communication flow: one with managers present and another with them absent (see Figure 5). "Sam" and "Ralph" represent managers in Figure 5. This provides a visual representation of how managers influence the flow of information throughout the department.

Implications for HRD Research and Practice

HRD researchers and practitioners have much to gain by utilizing the SNA methodology. More specifically, the identification of social structures within an organizational context will further our understanding of why individuals act and respond to various inputs. By looking at relational and attribute variables, the researcher will be able to view the individual within a group context, which will assist in the identification of pressures that exist. Uncovering these structural pressures will help to identify unique dynamics that impact an individual's ability to perform effectively.

Social Network Hypothesis for Research

Social network methods have been developed by research through the course of empirical investigation and the development of theory (Wasserman & Faust, 1994). As mentioned at the beginning of the article, social network theory is an interdisciplinary approach to measuring the social structure and environment within which individuals function. Individual-level hypotheses, which exist within the network perspective, include dyadic (multiplexity), monadic, network, and mixed dyadic-monadic (autocorrelation) hypotheses. An example of a dyadic hypothesis is friendship ties that lead to job opportunity ties. A monadic hypothesis would suggest that the more ties an individual has, the greater the likelihood for their success, which refers to

the level of social capital one possesses. An illustration of a network hypothesis would be that those groups within organizations with greater density of communication will perform better than those groups that are less dense. Finally, a mixed dyadic-monadic hypothesis might state that those individuals who have a tight relationship influence each other's opinions. Each type of hypotheses can form the basis for research and understanding of the structural environment in which individuals operate.

Other examples of how SNA can assist HRD researchers in predicting the dynamic of relations within an organization are vast and varied. Structural holes can help explain the upward mobility of an individual because of their ability to control the flow of career-related information within an organization (Burt, 1992, 1997; Mizruchi, 2000; Podolny & Baron, 1997); centrality measures can help predict perceived levels of power within organizational units (Bonacich, 1987; Brass & Burkhardt, 1992; Cook & Emerson, 1978; Ibarra & Andrews, 1993; Krackhardt, 1990); and a person's strength of tie can help to predict the transfer of knowledge from one work team to another (Cross et al., 2001; Hansen, 1999; Simonin, 1999; Stasser, Vaughan, & Stewart, 2000). The social network approach provides a vehicle for validating a set of assumptions, which is the way in which theory is developed (Lynham, 2002).

The social network perspective stresses the importance of relationships among interacting units to uncover the hidden pressures that exist within a network. Actors and their actions are interdependent: They do not necessarily act alone or in isolation. Therefore, it is important when studying an organization that a holistic approach is taken and the collections of both attribute and relational data be gathered. The combination of these data will help to determine the impact HRD has on an organization and increase the likelihood that the interventions introduced will be effective for the long term. The relational ties between actors represent channels for the flow of information of resources that can assist in the transfer of knowledge from the worker to the job. By understanding the network structure, HRD researchers will be able to identify either the opportunities for or the constraints on individual action. As a result, network models can help to conceptualize structure as lasting patterns of relations among actors and add to HRD theory building.

HRD researchers may consider utilizing SNA as a means to measure organizational change and its effect on social structure over time. Social network analysis has attempted to address the question of network changes over time (Feld, 1997; Morgan, Neal, & Carder, 1996; Suitor & Keeton, 1997; Wellman et al., 1997). It has been demonstrated that supportive ties are the most likely to persist and that frequent contact between network members is also associated with the persistence of relationships (Feld, 1997).

Another approach to SNA can include examining the interaction between groups and organizations. Why do certain groups work in silos? The network structure of groups may help to illustrate the deficiency in group interactivity. More specifically, if one department does not appear to be effectively collaborating with another department, it is possible that the structure of the network for both groups has resulted in a disconnect between them. Key individuals within each department may represent “bottlenecks” and therefore delaying the flow of information from one group to the next. The identification of these actors can help determine appropriate ways to open up the flow of information from one group to another. In addition to examining information flow between departments, it is also possible to analyze the interconnectivity between organizations. This can be helpful in identifying useful partnerships among different industries.

The Limitations of SNA

From a methodological perspective, the limitation to a SNA approach for “complete networks” is ensuring that the response rate to the network surveys is attainable. Unlike other analyses, complete response rates are required to conduct a complete network analysis. The SNA process is rather data intensive and requires long surveys and extensive interviews. However, the study of “ego networks” is not as limiting because these analyze the relationships that exist from the point of a particular individual and can be determined through the use of a traditional survey.

In addition to the mechanics of collecting the surveys, there is also the reality that many of the individuals involved in the analysis will become “exposed” as regards their position within the network. Social network questions are typically “sensitive” (Tourangeau, Rips, & Rasinski, 2000) or “threatening” (Sudman & Bradburn, 1982). In most cases, this becomes a deterrent for people to participate. However, if the collection of data is done in such a way as to encourage individuals to share their information and participants are brought in as partners of the research, complete response rates should not be a problem. Once data have been collected, analyzed and put in an understandable format, reporting to the individuals involved in the process should be arranged. The initial analysis represents the starting point for introducing interventions that will help deal with any issues discovered during the SNA (Cross & Parker, 2004).

In addition to being data intensive, conducting an SNA can be time sensitive when testing a treatment or intervention in a pre- and post-test design. When an analysis is conducted on the effectiveness of an intervention to alter the network structure, it is important to identify the appropriate amount of time between the pre- and post-test to determine the structural environment, which exists at the time of analysis and the impact any interventions may have had after its implementation. If the membership were to change in

any major way, the effectiveness of the intervention becomes more difficult to relate to the change in network structure if not conducted within a reasonable amount of time. However, intervention effects may have caused key actors to leave the network and should also be considered in the overall analysis. Traditional SNA methods measure specific moments in time, which can obviously change as membership changes. However, even if the network membership does change, the process in which the analysis is conducted may identify patterns that exist within a network. Uncovering these patterns will assist in determining the dynamics of a particular group's relatedness and the forces that enable them to function at a level that is in keeping with the organization's objectives. For research purposes, SNA will allow researchers to examine the social structure of an environment to help explain why certain phenomena exist within a given group. For example, an SNA can examine how prominent an actor is within a group through centrality measures. This example can lead to theory building in areas such as why certain individuals are more likely to get promoted than others and why some departments exhibit higher levels of collaboration. The examination of relationships through SNA will help to explain why developmental processes are affected by HRD interventions.

SNA in HRD Practice

The ability for an organization to identify the relationships that exist within the social structure of its environment is a powerful tool. If HRD practitioners are to deal with human capital issues, it is not enough to deal with the individualistic components to performance; they must pay attention to the relationships that impact the ability of individuals to function as a unit (Ahuja, 2000; Burt, 1997; Coleman, 1988). SNA can provide HRD practitioners with valuable relational information that can assist in the assessment of performance and implementation of interventions. The various SNA measures (i.e., centrality, density) can serve as an assessment to determine the right approach for intervention implementation. HRD practitioners are often confronted with learning transfer issues that have not demonstrated return on investment for the organization (Rouiller & Goldstein, 1993). The lack of learning transferred to the workplace may be due in part to the influences of the individuals who have participated in the training or those unwilling supervisors who have not bought in to the training in the first place. SNA can provide the HRD practitioner with an initial assessment of the social structure of the organization and allow them to identify the central employees who may be considered "opinion leaders" (Leonard-Barton, 1985; Rogers, 1983). Getting buy-in on the intervention from the identified individuals can occur prior to training implementation, therefore increasing the likelihood that the objectives of the program will be reinforced by a central figure of the network.

In addition, ensuring that there is a flow of information throughout the organization is critical to employee performance. There are those individuals who become "bottle necks" for information flow, and they can reduce the impact of an HRD intervention. Managers or supervisors who control the flow of information downward may cause a delay in productivity (Callan, 1993; DiPadova & Faerman, 1993; Johlke & Duhan, 2001). Providing timely information can be accomplished through the identification of individuals who control the flow of information by encouraging quick dissemination. SNA serves as a tool to accomplishing this by illustrating the social structure within an organizational context and determining the patterns of information flow.

From a practical perspective, SNA can provide unique insight into the HRD role and help to illuminate the impact relationships have on the practitioner's ability to affect change. SNA will allow the practitioner to examine the relational ties that may affect the transfer of information, resources, knowledge, and attitudes between individuals when attempting to introduce an intervention. The structural environment of the organization either provides opportunities for enhanced performance or may stifle individual action. A practitioner's ability to identify patterns within the social environment will assist them in affecting change in a shorter period of time. The identification of central actors within the organization will provide direct access to the flow of information, which can be used to disseminate change initiatives. Utilizing the SNA approach may help alleviate the resistance to change that is often associated with organizational reconfigurations such as downsizing, lay-offs or restructuring (Neumann, 1989; Isabella, 1990; Torevlied & Velner, 1998).

As described in a previous section, the measures that SNA produces will allow for the unique insight into the relational dynamics of why individuals respond to some HRD methods and not others. For example, change theory accounts for an individual's readiness to accept a new environment in which they work. Social implications are accounted for but are derived purely from an individualistic standpoint. Identifying the structural position of the individual within a given context may help to add to our knowledge of the dynamics involved due to the relationships that exist and the speed in which the change occurs.

Is social network theory applicable to the field of HRD? The answer is yes. Social network theory is unique in that it can assist in the theory building process of HRD as well as to provide a practical tool via social network analysis. This unique combination can assist not only the HRD practitioner but also the scholars who study the field of HRD. Some examples where SNA may assist in the further development of theory building in HRD include learning participation, learning transfer, performance improvement, and training design. SNA can determine the effects of a social envi-

ronment on learning participation through the identification of cultural influences and the impact social structure has on an individual's motivation to learn. Learning transfer can utilize centrality measures that may help identify key individuals among groups who, if identified prior to a learning event, may provide support to the transfer of learning obtained through the training. Performance improvement may be linked to increased levels of social capital, which can be measured through SNA and training design can incorporate SNA as a means for increasing the effectiveness of training programs by considering social structure of an environment and how its uniqueness may require customization.

Conclusion

This article has introduced social network analysis as a unique methodology for studying social relationships of importance to HRD. SNA will add significantly to the field by measuring the relations that exist between individuals and the impact those relations will have on human capital output. In addition, SNA will help further develop the field of HRD by enabling researchers to analyze the interaction between individuals and their environment. Social network analysis can add empirical rigor to such diverse areas as organizational change, instructional design and training delivery. The practical utility of SNA can assist HRD practitioners in measuring intervention effectiveness and its impact over time. As Swanson and Holton (1997) suggest, the field of HRD is a relatively new area and continues to explore new theories and methodologies. SNA may play an important role in moving HRD forward.

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