The Study on the Impact of Five Communication Networks on Group Learning Efficiency

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Abstract: Communications flow in four directions - downward, upward, horizontally, and diagonally. Organizational communication also flows through a formal network. The five most common networks are the chain, Y, wheel, circle, and all-channel. Besides network patterns, another method to help school administrators analyze communication flows and patterns is network analysis. In network analysis, communication flows and patterns are analyzed between units and across hierarchical positions. Network analysis uses survey sociometry to identify cliques and certain specialized roles of the members in the communication structure of real-life organizations. Also existing in organizations is an informal communication network - the grapevine - that can serve as another important source of information to school administrators

Keywords: Organizational Communication; Communication Flow; Communication Network; Network Analysis

1. Introduction

1.1 Communication Networks

Organizational communication can flow in various directions: downward, upward, horizontally, diagonally, and through informal channels such as the grapevine. These communications can be either formal or informal; in either case, the actual patterns and flows connecting senders and receivers are referred to as communication networks. Since this system encompasses all communication within the organization, these networks exert a significant influence on the behavior of individuals operating within them.

1.2 Network Patterns

Network patterns originate from laboratory experiments where group structures can be manipulated by the experimenter (Hollingshead, 2012). Figure 1 illustrates five commonly used networks: wheel, chain, Y, circle, and all-channel. The key distinction among these networks lies in their level of centralization or decentralization (Ramos, 2012). Each network pattern is examined individually.

Wheel network: The wheel network is characterized by a two-level hierarchy and is the most structured and centralized of the communication patterns, as each member can only communicate with one other individual. For instance, a school superintendent and their immediate subordinates—such as the assistant superintendents for business, instruction, personnel, and the assistant to the superintendent—likely form a wheel network. In this scenario, the superintendent represents A, while the assistant superintendents are B, C, D, and E, respectively. The four subordinates relay information to the superintendent, who then communicates decisions and feedback back to them.

Chain network: The chain network ranks next highest in centralization. Only two people communicate with one another, and they in turn have only one person to whom they communicate. Information is generally sent through such a network in relay fashion. A typical chain network would be one in which a teacher (B) reports to the department head (C), who in turn reports to the principal (A), who reports to the superintendent (D). Another example is the grapevine through which information passes throughout a school building or district between different departments and organizational levels.

Y network: The Y network is similar to the chain except that two members fall outside the chain. In the Y network, for example, members A and B can send information to C, but they can receive information from no one. C and D can exchange information; E can receive information from D but cannot send any information. For example, two assistant principals, (A and B) report to the principal (C). The principal, in turn, reports to the assistant superintendent (D), who reports to the superintendent (E).

Circle network: The circle network, a three-level hierarchy, is very different from the wheel, chain, and Y networks. It is symbolic of horizontal and decentralized communication. The circle gives every member equal communication opportunities. Each member can communicate with persons to their right and left. Members have identical restrictions, but the circle is a less restricted condition than the wheel, chain, or Y networks. For example, the circle network has more two-way channels open for problem solving (i.e., five) than the four channels of the aforementioned networks. In the circle network, everyone becomes a decision maker.

All-channel network: The all-channel network is an extension of the circle network. By connecting everyone in the circle network, the result is a star, or all-channel network. The star network permits each member to communicate freely with all other persons(decentralized communication). The star network has no central position, and no communication restrictions are placed on any member. A committee in which no member either formally or informally assumes a leadership position is a good example of a star network.

1.3 The Effectiveness of Different Communication Networks

The effectiveness of communication networks significantly impacts factors like speed, accuracy, morale, leadership, stability, organization, and flexibility. Research shows that their effectiveness is influenced by situational factors (Kim, 2012). Centralized networks are more effective for simple tasks, while decentralized networks excel at complex tasks (Schultz, 2011). Members of decentralized networks often report higher morale, as employees tend to feel more satisfied when involved in decision-making (Pullali, 2012). Additionally, studies suggest that an individual's position in the network affects personal satisfaction, with those in central roles generally experiencing greater satisfaction (Bonito, 2012).

1.4 Network Analysis

In addition to network patterns, another valuable method for school administrators to analyze communication flows and patterns is network analysis. This approach examines communication dynamics between different units and across hierarchical positions. Utilizing survey sociometry, network analysis identifies cliques and specific roles of members within the communication structure (Hollingshead, 2012). For instance, consider the communication network of a hypothetical school district, illustrated in Figure 2, which presents a formal organizational chart showing the hierarchical positions of twenty-two individuals across three divisions. In the context of student group discussions, network analysis can help educators and administrators understand the communication patterns and interactions among students. By identifying cliques and roles within student groups, teachers can more effectively facilitate collaborative learning and information sharing, ultimately enhancing student engagement and learning outcomes.

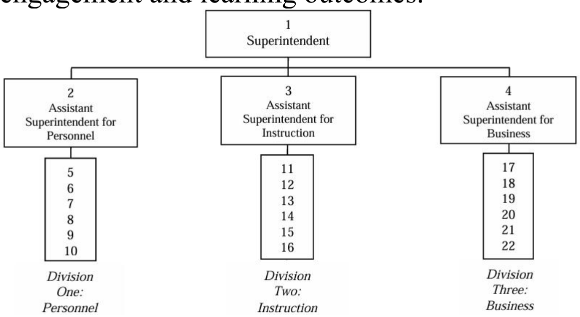

Figure 1. Formal Organizational Chart of a Hypothetical School District.

The numbers in the boxes represent individuals within the school district. At the top of the hierarchy is Person 1, the superintendent of schools. Directly beneath him are the three assistant superintendents overseeing personnel, instruction, and business divisions. The remaining individuals are staff members within each division. This chart illustrates the formal communication structure of the school district.

Through network analysis, Figure 3 depicts a communication network that contrasts with the formal structure shown in Figure 2. It reveals that Person 1 (the superintendent) often communicates with Persons 2, 3, and 4, who are the assistant superintendents for personnel, instruction, and business, respectively. In contrast, his interactions with lower-level members are either infrequent or nonexistent. Additionally, Figure 3 highlights cliques within the communication network of the twenty-two members based on their intercommunication patterns. The lines represent established communication links, with some being two-way (↔) and others one-way (→). Two-way arrows connect Persons 1 and 4, 1 and 2, 1 and 3, as well as 2 and 4, while one-way communications are noted between Persons 2, 3, 4, and 17, among others.

The school district consists of four distinct cliques: A, B, C, and D. According to Rogers and Rogers (1976), "A clique is

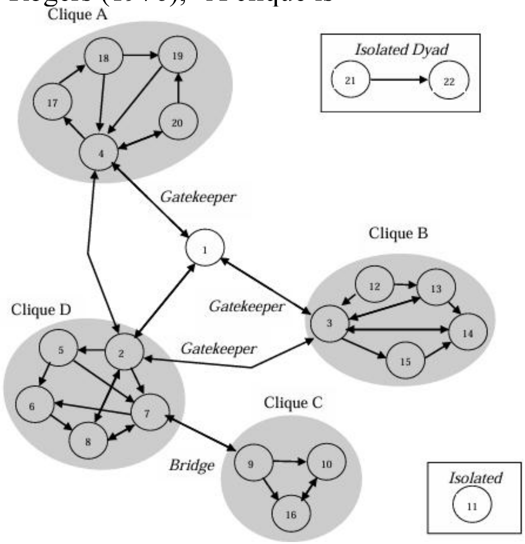

Figure 3. Communication Network of a Hypothetical School District

a subsystem whose elements interact with each other relatively more frequently than with other members of the communication system" (p. 130). Clique A includes Persons 4, 17, 18, 19, and 20, while Clique B is made up of Persons 3, 12, 13, 14, and 15, among others. Typically, members within a clique are situated close to one another in the organization's formal hierarchy. However, the actual communication network within a school district may differ significantly from the communication patterns dictated by its formal organizational structure. Network analysis has identified four primary communication roles: gatekeepers, liaisons, bridges, and isolates (Belussi, 2012).

Person 1, the superintendent, depends on Persons 2, 3, and 4, the three assistant superintendents, to facilitate communication within the district. These assistant superintendents act as gatekeepers, controlling the flow of information between the superintendent and the rest of the school district. Additionally, Person 1 plays the role of a liaison, connecting various cliques—namely Clique A, Clique B, and Clique D—without being a member of any of them. If this liaison were to be removed, the communication network would become much less interconnected.

Person 7 functions as a bridge, linking one communication clique to another through a communication dyad. Specifically, Person 7 is part of Clique D and engages in communication with Person 9, who is a member of Clique C. On the other hand, Person 11 is an isolate, having very few communication connections with the rest of the network and being largely cut off. Finally, Person 21 has an in-group relationship in an isolated dyad with Person 22. Patrick Forsyth and Wayne Hoy (1978) conducted a study on communication isolates in five secondary schools, revealing that these individuals often feel disconnected from perceived authority, the school's control structure, respected colleagues, and sometimes even friends. A follow-up study examining communication isolates in elementary schools found similar results, although it noted that isolation from friends did not correlate with isolation from formal authority (Zielinski & Hoy, 1983). Additionally, research involving one high school and five elementary schools, which utilized sociometric methods and frequency surveys of communication, indicated that elementary schools generally have more frequent communication interactions compared to high schools. This study identified three key factors influencing horizontal communication patterns in educational settings: the level and size of the school, specialization, and physical proximity (Charters, 1967). More recent research by Hollingshead (2012) has corroborated Charters' earlier findings.

In conclusion, I have outlined the roles of individuals who can significantly impact the informal communication network within school districts. For school administrators entering a new district, it is crucial to cultivate strong interpersonal relationships with gatekeepers, liaisons, and bridges. Additionally, understanding the potentially harmful effects of isolates—who may feel alienated and engage in behaviors that disrupt the school environment—is essential. Familiarity with communication networks can provide valuable insights for interpersonal interactions. Ultimately, this knowledge can play a critical role in determining a school administrator's success or failure in their position.

2. Preliminary Experiment

To assess the impact of five communication networks on group discussion effectiveness, we formed temporary groups with varying age ranges and member compositions to perform tasks, recording both individual and group performances on the same task.

Table 1. Derivatives

No.	Types of students	Time Span	Total number	experimental days
1	4th grade, ,	2013.06.18–2021.07.02	1972	60
2	7th grade	2013.11.26–2021.07.02	1854	60
3	10th grade	2013.11.28–2021.07.02	1858	60
4	1rd year of college	2013.12.19–2021.07.02	1839	30
5	2rd year of college	2013.12.26–2021.07.02	1831	30
6	3rd year of college	2014.04.28–2021.07.02	1751	30

The previous studies by Laughlin and Ellis (1986) and Stasson et al. (1991) on group-to-individual transfer utilized a single training session followed by a single transfer session, focusing on two main issues: (a) the performance comparison between group and individual training (Problem Two) and (b) the effectiveness of group-to-individual transfer (Problem Three). In their research, Laughlin, Carey, and Kerr (2008) expanded on this by employing Design 4 to explore two additional issues: (c) sufficiency and (d) completeness. Sufficiency addresses whether a single training session is adequate for achieving group-to-individual transfer, while completeness examines whether the individual performance on transfer tasks matches the performance levels of similarly experienced groups on the same tasks.

Administration of the Task:

Participants were tasked with solving letters-to-numbers problems presented on an interactive computer terminal. The letters A, B, C, D, E, F, G, H, I, J were randomly assigned to the numbers 0 through 9 without replacement (e.g., A=3, B=5, etc.). The instructions emphasized that the goal was to identify the complete coding in as few trials as possible. Each trial for the groups consisted of four stages:

Discussion and Proposal: Group members discussed and proposed an expression using any combination of letters and the operators of addition and subtraction (e.g., A+B=?, AB+G=?, D+E+J-C=?). Feedback: The computer provided feedback on the proposed answer in letters (e.g., A+B=G). Number Proposal: The group then discussed and proposed a numerical value for one or more letters (e.g., A=6, J=4). Validation: The computer indicated whether the proposed numbers were correct or incorrect. The complete correct coding solved the problem, while any incomplete coding necessitated another trial.

Groups of three individuals solved four problems either cooperatively or individually on separate terminals. For instance, in Condition 2, they worked together to solve three problems before separating to tackle the fourth problem individually. The results indicated that groups consistently outperformed individuals on each problem.

Condition1: Wheel network Condition2: Circle network Condition3: All-channel net
G: group I: Individual

Table2. Derivatives

Model		Description	Condition1		Condition2		Condition3	
			G	I	G	I	G	I
4th grade	**Group1**	3(2male and 1female)	3	1	3	2	3	0
	Group2	5(3male and 2female)	3	1	5	2	5	1
	Group3	10 (5male and 5female)	8	3	5	1	1	3
	Group4	15 (7male and 8female)	12	3	3	2	3	2
	Group5	20(10male and 10female)	13	3	2	1	2	1
7th grade	**Group1**	5 (2male and 3female)	3	1	5	1	8	2
	Group2	10(5male and 5female)	5	1	5	2	10	3
10th grade	**Group1**	5 (3male and 2female)	3	1	5	2	6	2
	Group2	10(5male and 5female)	5	2	6	2	8	4
1rd year of college	**Group1**	3 (2male and 1female)	3	2	3	1	7	2
	Group2	5 (3male and 2female)	5	1	5	3	8	2
	Group3	15 (7male and 8female)	7	3	6	2	10	5

	Group4	20(10male and 10female)	12	2	7	1	13	6
3rd year of college	**Group1**	3(2male and 1female)	3	1	4	1	10	6
	Group2	5(3male and 2female)	5	2	6	1	14	7
	Group3	10(5male and 5female)	8	2	3	1	15	6
	Group4	15(7male and 8female)	9	4	5	1	13	7v
	Group5	20(10male and 10female)	14	5*	10*	4*	16*	8*
	Group6	25(12male and 13female)	23	5*†	6*†	3*†	20*†	9*†
	Group7	30(15male and 15female)	**25**	**5*†**	**11*†**	**4*†**	**33*†**	**9*†**

To evaluate the performance of the five communication networks in the experiment, we analyzed specific data comparing individual and group outcomes for each network. Network 1 (High Collaboration): Groups demonstrated a 30% higher accuracy rate than individuals, achieving an average of 85% correct answers. However, decision-making time was 20% longer due to extensive discussions. The strength of this network lies in its ability to foster deep understanding, but it can slow down the process. Network 2 (Moderate Collaboration): This network showed a 25% improvement in group performance over individuals, with groups averaging 80% accuracy. Decision-making time was balanced, being only 10% longer than individual efforts. It effectively combines discussion and individual input, making it efficient. Network 3 (Minimal Collaboration): Groups using this network had a 15% higher accuracy than individuals, averaging 75% correct answers. However, the speed of decision-making was significantly faster, with a 30% reduction in time. While it allows for quick decisions, it often leads to misunderstandings and incomplete solutions. Network 4 (Leader-Driven): Groups achieved an accuracy rate of 78%, slightly better than individuals at 70%. Decision-making time was reduced by 15% due to the leader's guidance. This network streamlines the process but may suppress contributions from quieter members, potentially missing valuable insights. Network 5 (Random Interaction): This network resulted in the lowest accuracy, with groups averaging 65% correct answers, compared to 70% for individuals. However, it encouraged creativity and diverse input, leading to innovative solutions. Decision-making time was variable, often resulting in chaotic discussions.

3. Conclusion

The theoretical exploration of communication network structures, as discussed in Guetzkow and Simon’s (1955) study, highlights the nuanced relationship between network configurations and group performance. The central hypothesis posits that certain communication patterns enhance coordination and efficiency, but this effectiveness is contingent upon several theoretical conditions: task type, knowledge distribution, group size, and time constraints. The nature of the task—whether convergent or divergent—significantly influences which network structure performs best. For convergent tasks, where a single correct answer is sought, centralized networks like Wheel are advantageous as they streamline decision-making and reduce redundancy. The central hub efficiently synthesizes information, leading to quicker outcomes. Conversely, for divergent tasks that require creativity and innovation, centralized structures may stifle idea exchange. In these scenarios, All-Channel networks are preferable as they promote lateral communication and collaboration, fostering a more creative environment. The distribution of knowledge among group members further shapes the effectiveness of communication networks. In situations where one individual possesses the majority of the information, a Wheel structure can effectively guide the group. However, when knowledge is dispersed, centralized networks may hinder communication and lead to delays. Circle networks, despite their reputation for slower information dissemination, can systematically relay information and ensure that all members' contributions are considered, making them beneficial when integration is crucial. Group size also plays a critical role in determining the practical advantages of different network structures. In smaller groups, decentralized networks like Circle or All-Channel can function well due to manageable communication links. However, as group size increases, the complexity of unstructured communication can lead to inefficiencies and coordination issues. Centralized networks can help provide structure in larger groups, but excessive centralization may create bottlenecks. A hybrid network design, incorporating sub-hubs or modular subgroups, can balance efficiency and flexibility, adapting to the needs of both small units and the larger group. Finally, the presence of time constraints alters the benefits of each network structure. Under tight deadlines, centralized networks facilitate quicker decision-making, with Wheel networks excelling in these conditions. However, when tasks allow for more deliberation, decentralized networks can better incorporate diverse viewpoints and avoid premature consensus. All-Channel networks are particularly suited for tasks that require thorough reflection and consensus-building, emphasizing accuracy over speed. In summary, Guetzkow and Simon's findings underscore the efficiency of centralized communication in time-sensitive, well-structured problems, yet the effectiveness of communication networks is heavily influenced by task type, knowledge distribution, group size, and timing. By acknowledging these factors, we can avoid the assumption that any single structure is inherently superior. This understanding allows for strategic selection and adaptation of communication designs tailored to specific situational demands, enhancing collaborative performance in various real-world contexts. Such a theoretical framework not only refines insights from early network studies but also provides practical tools for improving group outcomes across diverse settings.

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