AN INVESTIGATION FOR A MULTIDISCIPLINARY SOCIAL NETWORK WITHIN AN ACADEMIC SETTING

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ABSTRACT

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Blau, in The Organization of Academic Work (1973), postulated that the formation of integrative multidisciplinary social networks within University communities is highly unlikely. He suggests that the high degree of departmental specialization makes communication between different academic fields difficult. Friedkin (1978), however, identified a multidisciplinary social network within the physical science departments of a major research institution and concluded that "...settings may exist in science where a fairly high degree of multidisciplinary integration is systematically fostered."

The present study examined Blau's postulation against Friedkin's conclusion by investigating for a multidisciplinary social network of the personnel involved with the energy education projects at Michigan State University in 1981. The investigation attempted to determine if multidisciplinary integration can exist in this research setting. The questions for the investigation were developed after a selective review of the literature concerning communication network concepts and procedures, as well as organizational structure and multidisciplinary interaction within the academic setting. The literature supported the

appropriateness and the value of using communication network concepts and procedures to identify multidisciplinary integration.

The participants were asked in this study to indicate their frequency of energy education related communication with other energy education personnel in terms of Berlo's three functions of communication: production, innovation and maintenance. The data collected was then analyzed by NEGOPY, a computer program developed by Richards (1975) which generates the communication structural properties of a given population's communication patterns. The analysis of the communication structural properties for the energy education personnel's communication patterns identified multidisciplinary social networks. Network structures were found to exist related to the content of the energy education research communication shared by the personnel involved with the projects. The membership in the communication network linkages and cliques were determined not to be restricted by formal departmental structure.

The finding of multidisciplinary integration supports Friedkin's conclusion that Blau's postulation cannot be generalized to all-academic institutions. The implication is that through additional similar studies, a generalization may be built which states multidisciplinary integration is likely to exist at research-oriented institutions, a conclusion which substantially limits Blau's postulation.

This dissertation is dedicated to my wife, Janet Stump, for her love and support of myself and our children, Michelle and Heidi. The dissertation is also dedicated to my parents, Robert and Gladys Stump, in acknowledgment of the love, dedication, and guidance they have provided for their children.

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PURPOSE AND ORGANIZATION

Study Overview

This study investigates the existence of a multidisciplinary social network of the energy education personnel at Michigan State University in 1981. The study's investigation tests Blau's (1973) postulation that a multidisciplinary network is unlikely against Friedkin's (1978) finding of such a network. Communication network concepts and analysis techniques are utilized in conducting the investigation. The results of the study are intended to add to the knowledge regarding the relationship of college and university structures with academic endeavors.

Introduction

An organization is intended to bring people together in a coordinated way to accomplish a defined purpose over a period of time (Porter, Lawler and Hackman, 1975). The organization's policies, procedures, and administrative structure provide order and direction for the members to contribute their particular skill and/or knowledge toward the realization of a desired purpose. Academic institutions like other public and private enterprises are organizations which require a complex administrative apparatus to organize and coordinate the academic work of faculty, staff, and students.

Although the organizational structure may appear similar, a college or university has only slight resemblance to the general conceptions of business or governmental organizations (Millet, 1962). Contrary to the typical structures of authority and communication found in most business or governmental agencies, the academic structure has significant authority and autonomy invested in its academic departments. The departments are characterized by their loose connection, separateness, and decision-making power (Woodburne, 1958).

The unique nature of the organizational structure of academic institutions has been studied and discussed by numerous authors (Dressel and Reichard, 1970; Blau, 1973; Perkins, 1973; and Mintzberg, 1979). However, Beyer and Lodahl (1976) in their review of the literature could not find a consensus on how universities should be viewed as formal organizations. The characteristics of a bureaucracy are found in the university administrative structure, but the level of decentralized control and authority found in the academic department is not consistent with the traditional bureaucratic model.

Mintzberg (1979), however, offers an enlightening view of the university structure. In his discussion of organizational structures, Mintzberg describes the decentralized bureaucracy of a university as a "professional bureaucracy." Such organizational structures are found by Mintzberg to exist where the environment is both complex and stable. An environment in which extensively educated professionals are required for complex work problems, but a stable enough environment to allow for an expected level of performance. The organizations which have this particular environment are law firms, hospitals, social work agencies as well as universities.

The structure of the organizations is decentralized because the work is too complex to be directly supervised (Beyer and Lodahl, 1976). The actual coordination of the work is based on the standard results expected of a professional in a given situation. The professional is given autonomy to carry out the work and a certain level of results are expected of the professional by the organization (Mintzberg, 1979).

The autonomy is supported as well by the fact that the training and indoctrination of the professional is actually more of a factor in setting the performance level than is the organization (Mintzberg, 1979). The professional's education process begins with formal schooling and is followed by internships and certification examinations to enter the field. The professional association then expects the professional to continually upgrade his/her skills, to stay abreast of new concepts, and to generate new knowledge. As a result, the professional is more often directed by his/her educational background and colleagues than by the organization within which the professional works.

Although the professional bureaucracy is an effective organizational response to a complex work environment, Mintzberg (1979) identifies major problems which arise within the professional bureaucracy caused by the professional's autonomy. The professional bureaucracy has difficulty in contending with professionals who are either incompetent or not loyal to the organization. Supervision and modification of a professional's skills are opposed by professions as an unwarranted interference. Regarding the latter problem, some professionals see the organization as a place to work within one's expertise and not a place to be involved with broader organizational concerns. Professionals often resist cooperating with and depending on other professionals as it may interfere with their own work success.

The strong and insular academic department as a professional bureaucracy is a relatively new and unique phenomenon to higher education in the United States. Until early in this century, the college faculty as a whole regularly met and decided upon academic policy and personnel matters for the school. The traditional organizational structure was slowly eroded, however, by the growth in size of universities, the rapid increase in knowledge, the growth of graduate study and research activities, and the gradual departmentalization of colleges and universities by distinctive disciplines (Dressel and Reichard, 1970; and Perkins, 1973).

This departmentalization was not pre-conceived as a well-defined system to manage the growing university (Dressel and Reichard, 1970). Rather, it was caused by the need for flexibility to carry out the diverse and changing functions of the university, and in particular, the increasing dimensions of research and knowledge which affected a reciprocal specialization by faculty members (Veysey, 1965). A scholar was no longer a botanist, but a botanist specializing in such areas as plant genetics, cellular structure, or taxonomy. The advancing knowledge and specialization prohibited a unified faculty reasonably aware of the university's major disciplines and the activities of their colleagues. Decisions on curricula and research, as well as, employment and promotion, could now only be made by those competent in the field. As a result, the department system brought together faculty of common disciplines in order for them to pursue their interests and to make decisions which a total faculty was incapable of making (Millet, 1962).

Although the authority and autonomy of the department has come as a logical result of size, specialization, and the necessity to delegate decision-making, Dressel and Reichard (1970) cite several criticisms of departmentalization in their review of selected literature on the advantages and disadvantages of the departmental organization. They find departmentalization criticized because it erodes university unity, central planning, and shared communication and because departments have become political and social forces for their own means. These criticisms are supported by Mintzberg's (1979) citation of the problems found within the professional bureaucracy.

Even in light of the disadvantages of departmentalization, the dynamics of higher education are seen by Tucker (1981) to require an academic structure of departmentalization by discipline. From his study of the literature and his analysis of the Florida state university system, Tucker feels that there is "...no better way to organize colleges and universities than through academic departments based on recognized disciplines. Almost all efforts to organize colleges and universities differently have failed, particularly those efforts in public institutions...."

The actual effect of the departmental structure on the overall operation of the university or college, however, has not been significantly researched. In fact, writers in the 1960's (Moran, 1968; Bolman, 1965; and McConnell, 1963) were calling for more research in the administration of higher education. McConnell (1963) cited so little research being done on how colleges and universities were organized and administered that the conceptual framework was lacking for the formulation of an investigative search. Bolman (1965) recommended investigations of the rigidity and communication problems of the department and college organization. Moran (1968) suggested studies on the effect of new scientific problems on academic structure.

The call for this research was answered by Peter Blau's seminal study in 1973. His book, The Organization of Academic Work (1973), provided the conceptual framework for further research of the university organization. In his study, Blau examined how academic performance at colleges and universities is affected by the structuring of human resources. In particular, he studied the influence of administrative structure on several factors which have indirect bearing on the teaching and research orientation of faculty. These factors included the size of the institution, decentralization of authority, faculty social integration, and patterns of faculty communication.

Blau's study is based on his investigation of the administrative structures and academic environments of 115 American universities and colleges. He examined their operations through surveys, on-campus interviews, and review of their organizational materials. One of Blau's findings from his investigation was concerned with the relationship of academic departmentalization and multidisciplinary integration. Because of the independence in which faculty can pursue their academic professions and because the highly specialized nature of the disciplines makes communication difficult between the fields, Blau concluded that academic departments are centers of academic networks, but multidisciplinary integration is unlikely in the academic setting.

Blau perceived the unlikely existence of multidisciplinary integration in the academic setting as an important issue for colleges and universities. The collegial atmosphere is intended to be an open and sharing environment of knowledge and ideas. If departmentalization and specialization have a deleterious effect on the academic environment, there is cause for concern for the effective advancement of academic pursuits.

Nearly all studies related to academic integration have been supportive of Blau's conclusion that integration exists within the academic department, but multidisciplinary integration is unlikely (Breiger, 1976; Crane, 1969 and 1972; Mulkay, Gilbert, and Wolgar, 1975; and Mullins, 1972). However, the studies supportive of Blau focused on single disciplines and not on research being conducted by faculty in different disciplines. Freidkin (1978) studied the research communication of 128 faculty in six physical science departments of an American university, which he described as an elite research institution. Acquiring data gathered by a questionnaire on their communication behavior, Friedkin found the faculty to be linked in a single network of research communication. Each of the faculty had one or more communication paths to each of the other faculty members. In addition, interdepartmental cliques were found to exist which had densities higher than that which existed within the individual departments. Friedkin did not find specialization to prohibit cohesion between the departments. Rather, he found linkages and cliques which were independent of departments. Friedkin suggested that multidisciplinary integration may exist in higher education, particularly in research oriented institutions.

Statement of the Problem

Friedkin's study suggests possible limitations of Blau's postulation that integrative multidisciplinary social networks within the academic setting is unlikely. The conclusion of Friedkin's study is that integrative multidisciplinary social networks can exist at least within the physical sciences faculty of a research institution.

The intent of this study is to further assess Blau's postulation by conducting an investigation for a multidisciplinary social network within the departments of a large land-grant university. The personnel composition of the social network investigated, as well as the setting, will differ from the previous studies which have tested Blau's postulation. Whereas the other studies sought social networks within physical science departments by asking only the physical science faculty who they communicated with related to academic research, this study will seek to identify a multidisciplinary social network of all faculty and staff involved in a recent research problem area, energy education. The study also alters the focus of previous studies from the social network of general research within selected academic departments to a social network of a specific research problem.

If the social network indeed exists, the study will also investigate the content and the structure of the network members' communication. The intent of this investigation is to analyse the members' communication patterns in relation to the network itself and with their department. The level of integration of the departments can be determined by this comparison. The communication content to be investigated focuses on Berlo's (1970) three types of communication--production, maintenance, and innovation. The level of involvement will be measured by identifying each participant's network position and amount of communication within the network.

The investigation for the social network will use a communication network analysis. This method utilizes a survey process and quantitative analysis to identify members of a network and the structure of their communication. The results of the communication network analysis identifies networks by communication patterns and the amount and type of involvement individuals have within the network.

The hypotheses for the study assume the existence of the social network(s) including communication content and cliques within the energy education personnel. The communication network analysis investigates for the validity of these hypotheses. The specific problem hypotheses are presented in the conclusion of the second chapter. The hypotheses are written in the second chapter because they are based on the literature review. A better understanding of the hypotheses can be gained by examining them in the context of their supporting literature.

In summary, this study uses a communication network analysis to investigate the existence of a social network of all faculty and staff involved in energy education projects at a major land-grant institution. Provided the network exists, the study further seeks to identify the communication function and the communication structure of the network. The intent of this investigation is to test Blau's (1973) postulation that multidisciplinary integration is unlikely within academic settings against Friedkin's (1978) finding that multidisciplinary integration is possible under certain circumstances.

Significance and Purpose of Study

The significance of the present study is that it attempts to add to the research on the administration of higher education. The need for this research was cited earlier in the chapter. Bolman (1965), McConnell (1963), and Moran (1968) decried the lack of investigative research on the administration of colleges and universities. Of particular importance to them was research on communication problems between departments and the relation of new scientific problems with academic structure. The concern about communication between academic departments was expressed also by Dressel and Reichard (1970). They criticize the lack of interdependence between academic departments. Blau (1973) responded to these concerns in his investigation of the effect of college and university structures on academic pursuits. One of his areas of study was interdepartmental communication in an academic setting. Blau described the existence of a multidisciplinary social network to be unlikely in a college setting. His postulation was generalized from a study of 115 American colleges. Blau's generalization is challenged, however, by Friedkin's (1978) finding of multidisciplinary integration within the physical science departments at a major research institution.

The present study specifically seeks to identify and analyse the existence of a multidisciplinary social network at a major land-grant institution. The study is intended to test the validity of Blau's claim and extend the meaning of Friedkin's finding by examining whether multidisciplinary integration can be found within the academic personnel responding to a research problem at a single academic setting. In writing The Organization of Academic Work, Blau hoped that his generalizations would be treated as a frame of reference for further research on the administration of colleges and universities. This study responds to his work and is intended to further explain how the structure of universities affects academic performance.

Limitations of the Study

The individual characteristics of the study may not be applicable to other campuses or to future similar studies of the same population. Such characteristics as network properties and type and level of faculty involvement may not be consistent in other research settings because of the dynamics inherent to college campuses and to the field of research. The forces influencing the dynamics of this type of study include the continual change in research activities, personnel, and client needs. It is also quite possible because of these continual changes and the relative autonomy existing within academe, that not all of the potential study population were identified and/or analyzed in the current study.

The study conclusions, however, have general applicability for future research and for consideration in higher education administration. The strength of the study's general application is in the conventional setting in which the study was conducted and in the utility of the methodology. The study site and the faculty research behavior studied are not idiosyncratic, but common at many other campuses. The methodology is a standard process which uses a computer program for data analysis. Because the computer program is based on algorithms the methodology, as well as, the overall study is replicable for future similar studies.

Background of Energy Education as a Research Problem at Michigan State University

Beginning with the 1973-74 international oil crisis, the economic and social life style of the American society was disrupted and drastically affected by petroleum scarcity and rising costs. Americans faced energy constraints which affected their living standards, particularly for heating, cooling, and transportation. Moreover, these constraints were seen by scientists not to be temporary but expected to last into the next century and beyond.

The energy crisis was caused by several factors not the least of which included the high energy consumption which had become a way of life in the United States, the dependence by the United States on importation of over fifty percent of its oil supply, and the regular petroleum price raises by the Organization of Petroleum Exporting Countries (OPEC). Regarding this latter factor, the United States paid $90 billion for petroleum in 1980, up from $60 billion in 1979 - even though Americans used substantially less oil (Bernstein, 1980). Exacerbating the situation was the unsettled political climate of the Mideast, the major supplier of United States imported oil. The flow of oil for export was often impeded due to wars, changes in political leaders, and violations of agreed upon oil exportation policies.

Because it was doubtful that the United States would ever again enjoy an era of cheap and abundant energy, the solution to the energy crisis was felt to be through both the development of alternative fuel supplies and energy conservation practices. These solutions have not, however, been easily and quickly developed and implemented. A new American energy ethic, as well as energy technology, has been difficult to develop after years of excessive use of inexpensively priced fuel supplies.

In the mid-1970's, institutions of higher education began fostering a new energy value system and technology. Colleges and universities gathered energy data and information, researched new energy concepts, and began training today's and tomorrow's leaders and technicians in energy concepts. Michigan State University responded to the energy education problem in character with its land-grant mission. The faculty and staff initiated a large number of energy research and energy education projects both off-campus and on-campus in such areas as agriculture, education, administration, and community development. These projects were in response to research ideas of personal and institutional origin, as well as, from research grants from Federal, State, and private funding sources.

Hagstrom's description (1965) of how scientists choose research problems provides additional insight to the manner in which Michigan State University and other universities responded to the energy crisis. Typically, problems for investigation are given to scientists or identified by the scientists themselves. The motivation for working on the problems includes the challenge of discovery, the potential for recognition, and the funding availability. If the problem is new and the solution(s) will be highly valued, an important dimension is added to the research problem. In these cases, many scientists including the best ones are attracted to the problem. The scientific effort during World War II and the "race for space" after the Russian satellite Sputnik orbited the Earth are examples of these special problems. The energy crisis offered these same factors of major national importance, a new area for investigation, and significant discoveries to be made. The large number of energy education projects at Michigan State University and at other universities is very understandable in light of the importance of the energy crisis problem.

Typically, applied research into problems like the energy crisis tends to be interdisciplinary (Hagstrom, 1965). Collaboration between scientists from different disciplines is often necessary to solve practical problems. Temporary interdisciplinary groups form to work on the problems, or projects related to the problem, and dissolve as the projects are completed, or the problem is solved. This study will investigate the existence of such interdisciplinary integration within the energy education personnel working on the energy crisis problem at Michigan State University in 1981. Blau has postulated that the existence of such integration is unlikely.

Organization of the Study

Chapter I consists of an overview, an introduction concerning studies of academic departments, the problem statement, the purpose and significance of the study, limitations of the study, the background of the problem setting, and the organization of the study.

Chapter II is a review of selected literature related to the purpose of the study. The review expands on the Blau and Friedkin studies and overviews the history, types, and functions of communication networks, as well as, network analysis. A statement of the problem hypotheses is given at the conclusion of the review.

The methodology of the study is described in Chapter III. The identification of the population, the method of investigation, the research setting, and the treatment of the data is explained in this chapter.

Chapter IV contains the results of the data analysis, as well as, the evaluation of the hypotheses.

Chapter V briefly summarizes the study, offers conclusions with a discussion of their implication for theory and practice in relation to Blau's postulation and Friedkin's finding, and completes the report of the study with suggestions for additional research.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The present study is a network analysis of the communication patterns of the 1981 energy education personnel at Michigan State University. Based on the results of the analysis, the study seeks to identify the existence of a multidisciplinary social network within this setting. The presence of such a social network would be unlikely according to Blau's (1973) postulation on the multidisciplinary integration of faculty. A postulation which was challenged by Friedkin's (1978) study which found a relatively integrated social network within the physical science departments at a major research institution. The present study tests Blau's postulation as it applies to a selected all-campus research problem at a major land-grant institution. In this manner, the study seeks to enhance the understanding of the level of integration of academic specialization within university environments.

A review of selected literature related to the study is presented in this chapter. The background, methodology, and findings of Blau and Friedkin, as well as, the concepts and research on networks and communication network structures, content, and analysis are presented in order to provide a foundation for the study's purpose and methodology. The chapter concludes with the problem hypotheses.

Multidisciplinary Integration

In The Organization of Academic Work (1973), Peter Blau attempted to answer questions about the influence of the administrative structure of colleges and universities on academic pursuits. He looked at such issues as the conditions necessary for academic innovation, the dependence of faculty research on collegial climate, the relationship of faculty authority to organizational structure, and the characteristics of the academic stratification system. Blau's work on these issues was intended to provide insight and suggestions which would be expanded upon and used to enhance the pursuit of knowledge in the higher education setting.

Blau's study began in 1968 when he collected data on 115 universities and colleges within the United States. These schools were a sample of all four year institutions granting liberal arts degrees in the mid-1960's. Specialty colleges such as junior colleges and teachers colleges were excluded from the study. The data were collected from three sources. First, the top administrators at all 115 schools were visited and interviewed regarding their administrative structures. In these visits, the researchers met with the president and/or the chief academic officers and discussed such topics as organizational structure, how authority was shared, and the creation or elimination of academic departments. The second source was publications and internal records. The academic institutions' own qualitative information was reviewed, as well as the tenth edition of the American Council on Education's American Universities and Colleges and the 1968 survey information of college faculty conducted by the American Association of University Professors. The final source was a survey of 2,577 of the investigated schools' faculty members which was conducted by the Survey Research Center at the University of Michigan in 1967. All but one school participated in the survey for an average of 23 participants per institution.

Blau utilized regression analysis techniques on his data to find the conditions which influenced selected characteristics of academic institutions. The procedure decomposed simple correlations between independent and dependent variables to show which associations were spurious or directly effected. From the data analysis, Blau discussed and offered generalizations about a variety of topics related to the effect of organizational structure on the academic process. For example, he presented postulations on the effect of institutional size on research, the process by which an academic specialty area becomes a department, and the relation of differentiated academic specialties with the overall academic environment. Blau described these research conclusions however as "highly tenuous and tentative." He felt that not enough research had taken place in academic settings to "...declare any causal precedence for the existing social conditions." He offered analyses from his study, however, as building blocks to encourage further research and testing toward a theory of the academic organization.

Blau's study of the relation of differentiated academic specialities with the overall academic environment found a positive relationship of increasing institutional size with increasing institutional differentiation at declining rates. Blau suggested and discussed several hypotheses to explain this finding. One of his hypotheses offered the idea that "...differentiation creates the interdependence necessary to integrate large numbers of employees into a common enterprise." However, Blau's discussion of this hypothesis arrived at a negative conclusion on the positive relationship of differentiation and integration within an academic institution.

In his discussion, Blau considered as a dilemma the specialization required of faculty for scientific progress and the social relationships faculty have with the colleagues in their own university. Because academic scholars and scientists have a strong orientation toward their individual discipline and seek support and stimulation from the specialists in their discipline, social integration and networking with other campus faculty essential for an academic community is lost. In other organizations, specialization causes an interdependence between departments for either parts, tools, or resource support related to the product. In an academic institution, however, specialties are not directly interdependent (Hagstrom, 1965). The members of each academic department can research and teach without interacting with faculty from other departments. In addition, the specialization itself causes difficulty in communication between the faculty of different disciplines. Because of the lack of familiarity with the speciality discipline, the academic research conducted by the faculty of a department is not readily understood by faculty outside of the discipline. This apparent inability to exchange work-related information is exacerbated by Bess' (1982) opinion that faculty generally lack interest in interpersonal work-relations with their academic colleagues in other departments because of status distinctions. Bess contends that faculty tend not to give full attention to other departments with fewer members and/or with less of a scholarly reputation than their own.

For these reasons, Blau postulated the formation of academic social networks to be essentially within the department and the formation of multidisciplinary social networks to be difficult and highly unlikely. The differentiation of universities into departments based on academic disciplines has been essential for progress in the specialty disciplines. The differentiation has, however, caused obstacles to multidisciplinary communication about scholarly matters.

Since Blau's study, most research on the social networks of faculty focused on the activities of the scientists within a single discipline (Breiger, 1976; Crane 1969 and 1972; Mulkay, Gilbert, and Wolgar, 1975; and Mullins, 1972). These studies found scientists to be connected by a discipline network to researchers at other campuses and project centers. Price (1963) described this network as an "invisible college". Through these networks, scientists received research information and respond to and support the work of other scientists which is critical to the progress of research. In effect, social structures have developed around the communication of research information (Mullins, 1968).

More recently, Friedkin (1978) examined the social network of scientists in different disciplines at a single institution and found an integrative social network existing within the multidisciplinary population. Friedkin studied the pattern of research communication for the faculty of six physical science departments at an American mid-west university, which he described as an elite research institution. Using a survey questionnaire listing the names of all of the faculty in the six physical science departments, Friedkin asked the faculty to indicate with whom on the list did they have at least three conversations about research problems during the academic year. Based on a 58% response, Friedkin found that 128 of the 133 faculty were linked by one or more communication paths into a single network.

Friedkin (1978) broke the network into sub-networks of direct one to one contacts or linkages and found the six networks with the highest degree of direct linking to be multidisciplinary. He also found 39% of the linkages to be multidisciplinary. Departmental boundaries were of no effect on the social network patterns for these physical science disciplines. Friedkin concluded that academic specialization by departments does not appear to automatically constrain multidisciplinary social networks. Friedkin suggested that research oriented universities may be settings where multidisciplinary integration is fostered.

The present study extends Friedkin's finding that multidisciplinary integration may be fostered in research oriented institutions against Blau's postulation that such integration is unlikely. The study is conducted utilizing network concepts and communication network analysis techniques. The nature of these concepts and the basis for their application in this study is presented in the following sections.

Networks

As evidenced by Barnes' (1979) observations and Freeman's (1976) bibliography of social networks, the concept of network is becoming increasingly popular among social scientists to describe and understand social relations. The rising popularity of the network concept is attributed by Whitten and Wolfe (1973) to its effectiveness in identifying and studying clusters of informal relations within a system; an approach which has only recently been formalized and supported by computer technology.

The term network is similar to the idea of a group; except "network is distinct from 'group' in that it (network) refers to a number of individuals (or other units) who persistently interact with one another in accordance with established patterns" (Rogers and Agarwala-Rogers, 1976). Thus, the regular interaction of network members differs from group members who may not consistently interact with one another in a continual pattern. The established patterns of a network are based on the participants' communication relationships and common concerns or interests. For example, a network may form around a common problem or a common attraction to the arts, sports, or hobbies. Whatever the reason for the network's existence, the patterns of the members' communication provide definition and structure to the network.

Sociologists and communication specialists have found networks to be a rich source for studying behavior.Researchers like Boissevain (1974), Rogers and Agarwala-Rogers (1976), and Farace (1978) have found that the behavioral patterns of the network members can be understood by analysing the characteristics of the network structure and the network members. These behavioral studies are possible because network analysis identifies the level and type of relationship each network member has with other network members. This relationship data is then utilized in investigating whether the network's members have an affect on other individual network member's behavior. With an analysis of each participant's involvement level and personal characteristics, a selected trait or knowledge can be traced through the network channels and investigated in relation to the individual's behavior. Indeed, research by Boissevain (1974), Lin (1973), Rogers (1983), and others have well documented the influence communication networks can have on the acceptance of new ideas, practices, and innovations by people in various cultural and organizational settings.

In addition to their effect on member behavior, communication networks have been studied for their relationship to the formal organization in which they exist (Jacobson and Seashore, 1951; and Weiss and Jacobson, 1955). In this approach, the informal network is identified within the organization and its structural properties (i.e. cliques, liaisons, isolates, etc.) are analysed against the formal structure and its desired communication patterns. These studies not only establish the existence of an informal network within the formal organizational structure, they also can be beneficial for identifying how communication flow can be enhanced within the organization's system and what role the network has on the organization's goals (Taylor, 1976).

Clarifications

Before proceeding into the history and application of network concepts, it is important to clarify the term network as it is used in this study. The contributors to the network literature are so varied in their background and perspective of social behavior that their discussions on networks can be confusing. Indeed, Barnes (1972) describes network literature as "a terminological jungle in which any newcomer may plant a tree." Because of their relation to the purpose and approach of this study, three particular issues are presented at this point to assist the reader in understanding networks and the writing perspective.

The first issue to clarify is that the concept of network is not a theory (Barnes, 1972; Hammer, 1979; and Mitchell, 1974). Rather, as a concept, network means that certain people are informally interacting with each other in a regular patterned way. As mentioned earlier, not all aggregates of people are a network, unless there are consistent communication patterns. The actual existence of a group of people as a network must be established empirically through network analysis, a research approach for investigating and labeling a particular set of social reactions. Until the communication relationships are established between an organization's members, it cannot be assumed that a network exists solely because people and communication channels are present within an organization (Boissevain, 1974). In addition, knowledge of the structure and function of communication in one system's network does not necessarily predict the behavior and relations in another system's network. Networks are a concept for labeling and describing behavior, but not for predicting behavior (Burt, 1980).

Second, the term network is used to refer to an aggregate of people who are regularly interacting with each other as defined above. However, the term often describes in the literature an approach for identifying a network and its structural properties and content by studying and explaining a study population's social relations. For this paper, network means an aggregate of persons who by their pattern of regular interaction are a network. Network analysis is the term which will be used to signify a research method for identifying a network and its communication structure and function.

The final clarification to be made concerns networks, social networks, and communication networks. Networks are referred to in the literature as social networks by sociologists and social anthropologists, and as communication networks by communication specialists. Descriptions by Rogers and Kincaid (1981) for communication networks and by Mitchell (1974) and Boissevain (1974) for social networks will be presented to explain a subtle difference. In concept, the terms are very similar; each network description refers to an aggregrate of people with patterned relationships. The communication network concept however emphasizes more the identification and interpretation of communication patterns in determining a communication network and its properties. The communication network analysist will begin researching a selected population of people by identifying communication relationships and the nature of the relationships. The structure and function of communication will be established from this data and the communication patterns and content will be studied for their affect on behavior.

The sociologist defines a social network from a more macro-level approach and views the social network as slightly apart from the communication network. For this reason, the sociologist identifies a social network through focusing on the communication content and the personal relationships rather than on the communication patterns. Choosing a behavior to study within a given population, the sociologist will identify the existence of the behavior in the network and how the behavior influences and is influenced by the personal relationships. Using dominance as an example of a behavior which a sociologist might study within a given population for its affect on relationships, the sociologist's attention would concentrate more on the dominance behavior itself than on the communication roles played by the network members. As a result, a social network could include individuals who rarely or never share interpersonal communication (Rogers and Agarwala-Rogers, 1976). In comparison, the communication network would include only those individuals who have consistent communication patterns.

A discussion of the differences between social networks and communication networks is akin to splitting hairs. Nonetheless, the presentation establishes a frame of reference from which to understand the nuances of the network literature, as well as, the perspective utilized in approaching the study's problem. This study utilizes the terms network, social network, and communication network interchangeably. There is no intent to signify any substantial difference between them. In that the purpose of this study is to investigate the existence of interdisciplinary communication, the communication concept of network is the chosen methodological approach.

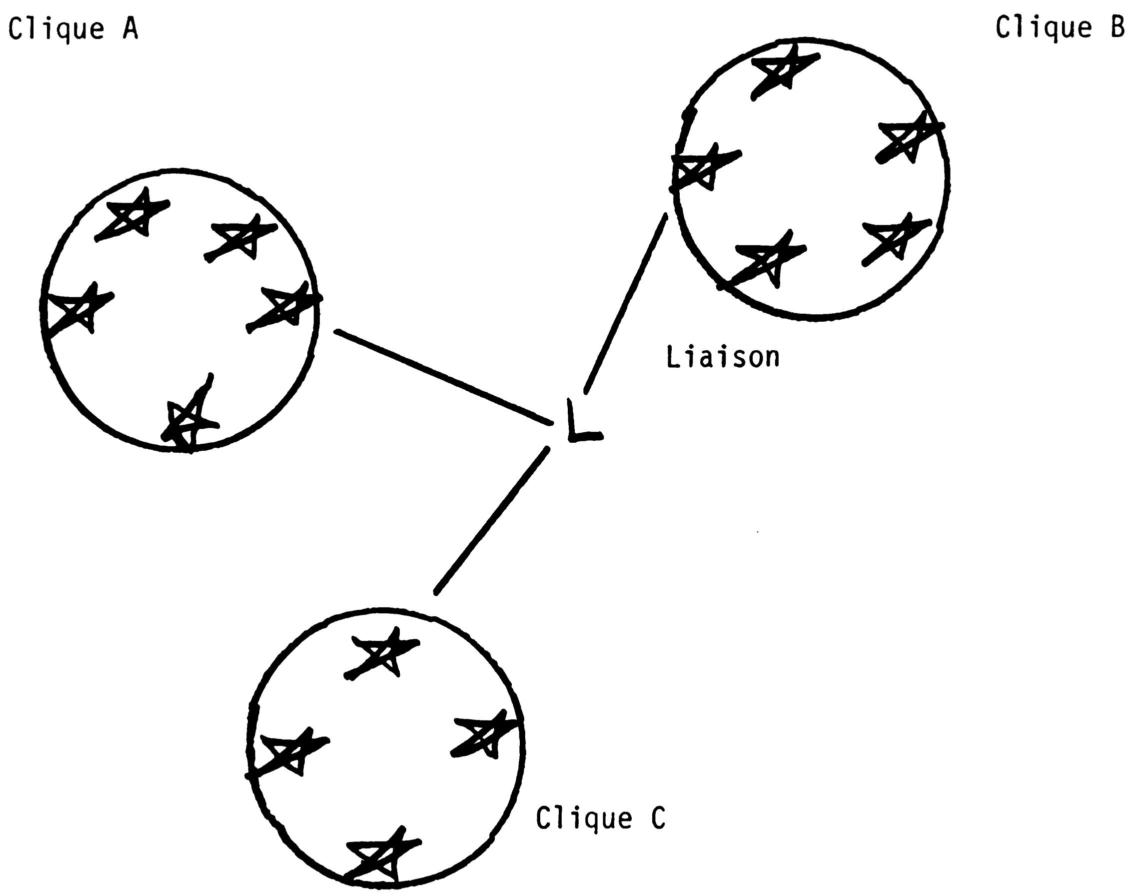
To assist the reader in further understanding this study, a glossary of terms is provided in Appendix A. The glossary defines such terms as cliques, reciprocation, density, and networks; words which are used often in this report.

Historical Background

The foundations for network concepts and methodology originate in sociology, particularly sociometry, and in the social psychological small group studies of the 1950's which were performed in laboratory settings (Farace, Monge, and Russell, 1977). Georg Simmel is generally recognized as one of the first sociologists to recognize the effect of network relationships on individual behavior. In 1922, Simmel published The Web of Group-Affiliations which introduced the concept of informal networks (Rogers and Kincaid, 1981). To understand human behavior, Simmel studied the system in which the individual participated for interpersonal relationships that influenced the individual's behavior. Simmel's approach differed from the predominant concepts of the time which focused on the individual for behavioral causes. Rogers and Bhowmik (1971) describe the prevalent methodological approach during this era to be the study of intrapersonal characteristics, leaving interactive relationships largely neglected. Although his ideas offered a significant new insight into behavior, Simmel's work was limited by the lack of a satisfactory means to measure network relationships (Rogers and Kincaid, 1981). The measurement technique to collect quantitative data on these network relationship's was provided in the mid-1930's by Jacob Moreno's sociometry (Moreno, 1953).

Sociometry is described by Chapin (1940) as a generic term for the measurement of societal and interpersonal relationships. The sociometry method determines these relationships by directly questioning respondents about their social relations (Mouton, Blake, and Fruchter, 1955). For instance, a respondent may be asked questions regarding with whom they speak with the most, or with whom they discuss certain issues. The sociometry method then portrays the collected data in a sociogram (see Figure 2-1) as a graphic of the communication patterns or social relationships (Moreno, 1953).

In reviewing the history of sociometry, Nehnevajsa (1955) found the sociometry method to have had a significant impact on contemporary behavioral research and theory. Sociometry deeply influenced the theoretical and conceptual development of group dynamics, role playing, psychodrama, socialization, and spontaneity. In addition, Rogers and Kincaid (1981) cite Moreno's research on communication patterns as a primary source for much of present day network analysis. Of particular importance to the development of these theories and concepts was sociometry's methodology of systematic data reports in contrast to intuitive observation (White, Boorman, and Brieger, 1976).



Key to Symbols
★ - Clique member
L - Liaison
—— - Clique link indicating who is communicating with whom

Figure 2-1

Sociogram of three communication cliques joined by a liaison.

Although sociometry has proven to be a useful investigative tool and has been a foundation for modern measurement techniques, a drawback to the technique is that it can be applied to a maximum size network of only 80-100 people. As the study size increases, it becomes impossibly difficult to draw sociograms. In addition to being an arduous task, the drawing of the sociogram cannot necessarily be replicated due to the lack of systematic rules (Farace, Monge, and Russell, 1977). For these reasons, the sociometry approach did not maintain significant scholarly interest beyond the 1940's, although interest in communication networks and network analysis did not perish (Rogers and Kincaid, 1981).

The interest was maintained by three centers of research which are often cited in the literature for their role in carrying forward the studies of communication networks in the 1950's and 1960's. Anthropologists in Europe led by Bott (1955), Mitchell (1969), and Boissevain (1974), studied the effect of communities on individual behavior. In their studies, which were concentrated on very small networks often of families and neighborhoods, they found significant community influence on the behavior of individuals. At approximately the same time in the early 1950's, research on network analysis of organizational communication was occurring at the University of Michigan. Led by Jacobson, Seashore, and Weiss, these researchers investigated the organization communication patterns of the regular work-related interpersonal communication between organization members (Schwartz and Jacobson, 1977). Using the sociometry research approach, Jacobson and Seashore (1951) and Weiss and Jacobson (1955) identified the communication cliques and the liaisons linking the cliques as an informal structure within the organization and compared the informal structure with the formal structure. From these comparisons, generalizations were developed on the communication efficiency of the organization and the relationship between the informal and formal structures.

In addition to advancing the studies in communication networks, the research conducted at the University of Michigan was significant for continuing the methodological shift from focusing on individuals to an analysis of communication relationships (Rogers and Agarwala-Rogers, 1976). Rather than studying the functions and characteristics of individuals in organizations, Jacobson, et al. studied the whole organizational system for communication patterns of relationships.

While the studies by Jacobson, et al. were being conducted within organizations, studies of communication patterns were also being conducted by Bavelas (1948), Leavitt (1950), and Shaw (1964) within laboratory small groups. These researchers were concerned about the relationship of fixed communication patterns upon group process. In their laboratory studies, they experimented with various structural patterns of communication networks on such dependent variables as group efficiency, member satisfaction, perception of leadership, and member adaptation (Shaw, 1964). The results of their experimentations included the conclusion that the greater the interconnectedness of a network, the greater the member satisfaction, as well as, the better the group's problem-solving efficiency on less routine tasks. (Shaw, 1964).

The overall laboratory methodology and results are criticized however by Rogers and Agarwala-Rogers (1976), Burgess (1968), and other social scientists. The primary criticism is that studies replicating their work often concluded with confusing and contradictory results (Freeman, 1978). In addition, the experimental results were found to lack reliability outside of, as well as, within the laboratory. This reliability problem may be related to a second criticism that the laboratory "conditions did not reflect the real life situations of large organizations" (Rogers and Agarwala-Rogers, 1976). Unaccounted for in the experiments was the influence on individuals and groups which established integrated networks have within an organization.

Although the conclusions of the small group laboratory studies may be limited in value, the contribution of these small-group studies to network analysis is significant in that they generated information and interest regarding the structural effects of communication networks on network members. In particular, Bavelas' idea of structural centrality (the network participants' degree of connectedness) provided impetus for many follow-up experiments (Freeman, 1978).

The results of these network studies conducted at the three research centers did not have an immediate and significant impact on the study of behavior. The primary focus of the field continued to be on the analysis of the individual for explanations of behavior (Rogers and Kincaid, 1981). The traditional approach was supported by the advent in the 1950's of computers capable of manipulating large quantities of data on individuals. Similar computer technology to analyse communication relationships as the unit of study was not available until the 1970's. Consequently, the design of a sociogram displaying communication relationships for a network of 100 could take weeks to design and then not necessarily represent an accurate picture of the communication patterns. The availability of computer technology for individual-based data and the lack of the same for relationship-based data resulted in a dormant period for network studies in the late 1950's and the 1960's (Rogers and Kincaid, 1981).

In the early 1970's, however, several computer methods became available for the network analysis of large systems. The computer analysis methods include NEGOPY, CONCOR, SOCK/COMPLT, and CLIQUE (Rogers and Kincaid, 1981). The common procedure for all of these computer methods is described by Rogers and Kincaid (1981) as the use of a matrix to order the data of who is communicating with whom

Table 2-1

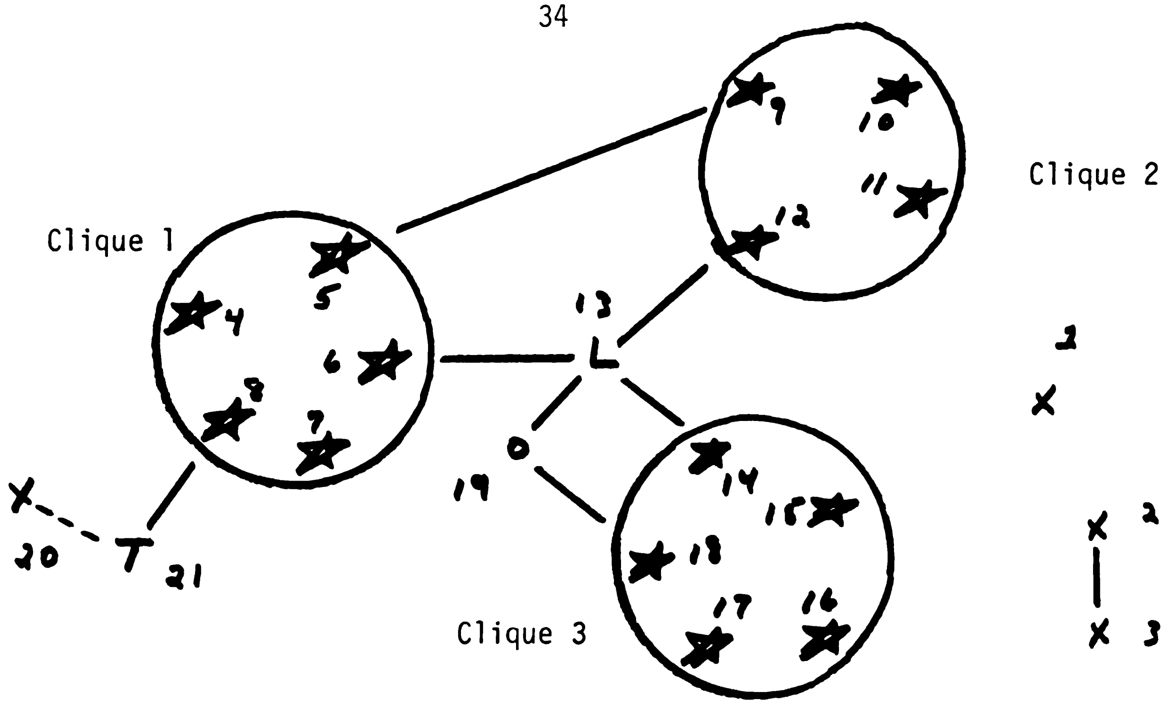
Who-to-whom communication matrix.

"Whom"

		#10	#11	#12	#13	#14	#15	#16	#17
	#10	-	2	3	0	0	0	4	0
	#11	2	-	1	0	3	1	2	1
	#12	3	1	-	3	2	3	1	0
"Who"	#13	0	0	3	-	4	0	2	1
	#14	0	3	2	4	-	4	2	2
	#15	0	1	3	0	4	-	1	1
	#16	4	2	1	2	2	1	-	0
	#17	0	1	0	1	2	1	0	-

Note: These data represent who is communicating with whom and for how many hours per month. For example, #10 is communicating two hours per month with #11, three hours per month with #12, four hours per month with #16 and not at all with #13, #14, #15, and #17.

(see Table 2-1). In the matrix, each participant is listed on the "who" and "with whom" dimensions. The reported frequencies of dyadic interaction are then entered into the N x N matrix set and applying an algorithm, a specific mathematical and procedural criteria, the computer generates an analysis of the data. The results of each computer method, however, emphasizes a different set of network structural properties.



Cliques:
- Clique 1 - 4,5,6,7,8
- Clique 2 - 9,10,11,12
- Clique 3 - 14,15,16,17,18

Group Linkers
- Bridges - 5,9
  - Liaison - 13
  - Other - 19

Key to Symbols
- O - Clique
- ★ - Clique Member
- x - Isolate
- ---- - Isolate Link
- —— - Group Link
- T - Tree Node
- L - Liaison
- • - Other

Isolates
- Isolated Dyad - 2,3
- Isolate Type One - 1
- Isolate Type Two - 20
- Tree Node - 21

Figure 2-2.

Illustration of a network and selected communication roles. [Based on a similar figure by Farace, Monge, and Russell (1980)]

For instance, Farace and Mabee (1978) describe CONCOR as a group-detection devise and NEGOPY as a means for identifying cliques and network property measures.

Of most importance is that all of the methods cope with the primary problem of analysing the large volumes of data which are found in communication network studies. A second advantage of the computer methods is their standardization of analysis. Because strict algorithms are assigned to the analysis procedures, the subjective nature of determining communication structures is removed. With these methodological breakthroughs, social scientists could now conduct studies on topics which had previously been unapproachable. The advent of computer technology in the 1970's sparked a new surge of interest in network analysis (Rogers and Kincaid, 1981).

Network Analysis

Network analysis is a research method for identifying a system's communication structure and function based on the study of interpersonal relationships (Rogers and Agarwala-Rogers, 1977). From the analysis, a systematic picture is composed of the interpersonal relationships' social structure (Knoke and Kuklinski, 1982). The social structure's picture is called a network existing within the system.

A glossary of terms is provided in Appendix A to assist the reader in better understanding a network and its properties. In addition, figure 2-2 provides a visual illustration of a network. Such terms as cliques, liaisons, and isolates are presented in the figure and in the glossary.

The network analysis may be accomplished at several levels and from two different frames of reference or approaches (Burt, 1980). The level of analysis may concentrate on the individual, the system's sub-groups or cliques, or the total system level (Knoke and Kuklinski, 1982). The frames of reference for analysing these levels are described by Burt (1980) as the relational approach and the positional approach. In a relational approach, the content and the intensity of each relationship is described for the units analysed.

The intensity of the relationship is measured by the frequency of exchange, the greater the reported frequency of interaction, the stronger the relationship. The relationship's content is the function of the communication shared. The communication functions could be for work information, new ideas and practices, or interpersonal support (Berlo, 1970).

The status and role of the units of analysis are described in a positional approach, the second frame of reference. Again, as in the relational approach, the position's strength is measured by the frequency of the exchanges for the unit. The positional approach differs however from the relational approach in that the unit of analysis is referenced against all other units of analysis within the system, whether a relationship exists or not, to determine the unit's role or status in the system. This approach allows for measures of social integration and configuration which reveals a specific network structure. For example, a unit of analysis can be isolated or be a central figure (e.g. bridge or liaison) in the network based on the frequency and type of relationships it has with other units.

This dual analysis provides a description of the unit's communication structural properties and content. Networks can now be generated based on overall communication or selected functional content to illustrate how and where certain types of information are flowing through the system. The roles and the degrees of relationship can also be defined for the units of analysis indicating: (1) how connected or integrated the units are with each other; (2) the units who are bridges, isolates or liaisons; and (3) the cliques within the total system (Rogers and Agarwala-Rogers, 1976). With this information, a social scientist can study the relationship of the network's content and structural characteristics on individual and group behavior. The network can also be related to the system's formal structure for comparisons of their structural properties.

This latter property of network analysis is the reason for network analysis' selection as the methodology in the present study. Because the study attempts to identify a multidisciplinary network within a formal organizational structure, the network members would necessarily have communication relationships which connect across the formal structural lines (if the network exists). Network analysis can identify a network from the communication relationships within the system and describe the network's communication structure. The network can then be compared with the formal organizational structure to test for differentiation between the two structures.

Communication Structure and Content

The products of the communication network analysis in the present study are the communication structure and content of the investigated population. These results are necessary to determine the level of multidisciplinary integration within the energy education personnel, the study problem. Although communication structure and content have been introduced in reviewing the selected literature related to networks and network analysis, they are presented as a separate section to provide a clear and distinct understanding of their concepts, particularly as they concern this study.

Farace, Monge, and Russell (1977) define communication structure as repetitive patterns of interaction which occur within members of a system. The patterns of interaction are based on communication content. Monge, Edwards, and Kirste (1978) in reviewing the literature assert that the repetitive relationships of a system may serve several different purposes and have a variety of content. For this reason, communication networks based on the different content of the relationships may differ in structure. For example within the same system, the network of work-related communication could be quite different from the friendship network of informal social relations, even though some relationships may be the same for both types of communication content.

Communication Content

A meaningful way to look at the content of communication within an organization is through Berlo's (1970) three functions of communication: production, maintenance, and innovation. Berlo's categorization can be used to examine any communication relationship for content by determining the function the communication serves in the relationship. The relationship itself may be based on one or more of these three major communication functions (MacDonald, 1970).

Production is described by Berlo (1970) as communication related to getting the job done. It is a mechanism of control. Messages related to specifications and amount and type of work are included in the production category.

While production communication is serving to complete the day-to-day work, innovation is communication related to new ideas and practices. Innovation communication provides the sensitivity to the changes taking place which the formal work-related network may be missing. The innovation network is critical to the long term survival of the system (Farace, 1978).

Maintenance refers to that communication which establishes and improves self-image, inter-personal relations, and attitude toward the organization. The maintenance function is referred to by Farace and Connelly (1970) as the communication which serves to encourage the smooth operation of the organization and its members. This function differs from the other two functions in that system outputs are not directly concerned (Albrecht, 1978). Often in studying the maintenance function in a system, researchers will further define it into subfunctions of maintenance of self-concept, maintenance of interpersonal relations, and maintenance of the production and innovation functions (Farace and Connelly, 1970).

Monge, Edwards, and Kirste (1978) in their review of research related to communication content have found two difficulties as well as emerging trends within the studies. The first difficulty is that the results of the studies are difficult to compare because of terminology and operational differences. The second concern is for the capability of the study populations to discriminate reliably between Berlo's fairly similar content categories. If the survey instrument does not present clear and understandable descriptions of the functional behavior sought by the researcher, the survey respondents may not provide valid data (Erickson et al., 1981).

The results of the communication content studies, however, have been summarized by Monge, Russell, and Kirste (1978) into interesting trends. One conclusion is a possible relationship between certain types of content and the role expectations of network members. The communication content shared by subordinates with superiors and by superiors with subordinates can vary by amount and type in terms of quantity. The channels of communication can also vary with the type of content. For example, face to face communication was found to be related to production content. The content channels can be influenced, however, by the system's social atmosphere.

The benefit of studying the content of communication in terms of networks is to understand the system's communication patterns of production, maintenance, and innovation. For the present study, the stated content networks as well as the overall communication network related to energy education can be compared with the existing departmental structure for multidisciplinary integration. The content network which exhibits the greatest multidisciplinary connectedness or density is important to determine because it offers insight into the possible causes for the existing level of integration.

Communication Structure

Farace and Mabee (1978) describe three broad categories of communication structure properties which can be revealed by network analysis procedures. The terms used in describing the structural properties may be uncommon to the general reader. For this reason, the reader may again be aided in comprehending this material by a glossary of terms which is available in Appendix A.

The first category of communication structure are the properties of the structure as a whole, including structure size and density and the number and size of detectable cliques. The second category are the properties of the cliques, including the number of members and the density within each clique, and the relationship of each clique with other structural components. The last category is the individual member properties, including the number of dyads, communication roles(s), and density.

The benefit of looking at the communication structure as a whole is to determine the size of the network and its level of density. This perspective also displays how the network is divided into cliques and individual members (Farace and Johnson, 1974). The level of density of the whole network is measured in terms of the "percentage of existing within network relationships out of the total number of such relationships which would have been theoretically possible" (Monge, Edwards, and Kirste, 1978). This measure indicates the relative integration of the respondents in the network (Albrecht, 1978). The density measure is influenced however by system size, with large systems having a lower percentage of density because of the difficulty in communicating with all members (Friedkin, 1981).

Boissevain (1974) describes a clique, the second category of structural properties, as clusters of network members who have a relatively high density. These network members are speaking more regularly with each other than they are with the other network members. The existence of cliques in the present study would be an indication of multidisciplinary integration.

Farace and Johnson (1974) and Rogers and Agarwala-Rogers (1976) describe several variables which can be measured at the clique level. The first measure is group size. The size of a clique can be three or more members depending on the parameter used for the level of interaction. For example the computer method of analysis, NEGOPY, can set the number of linkages for a clique member to be 50% or more of his/her total network linkages. This parameter can be raised to a higher percentage and thus affect the clique's size and inner connectedness.

A second measure at the clique level is clique dominance or the degree to which the pattern of communication within a clique is dominated by one or more individuals. This measure may illustrate the importance of an individual's communication role in the clique.

The degree of density of a clique can be assessed of the members within the clique and of the clique with other cliques. As in the previous measure for density of the whole system, the measure of connectedness of the individuals within the clique and between the cliques of the network is based on the percentage of actual linkages against the possible number of linkages (Rogers and Kincaid, 1981). A high degree of density within a clique would indicate the members have extensive and strong links. The existence of strong density also suggests a similarity of knowledge and attitudes within the clique members (Farace, Monge, and Russell, 1977).

LOW DENSITY

$\frac{\text{Actual Linkages}}{\text{Possible Linkages}} = \frac{8}{10} = .8$

HIGH DENSITY

$\frac{\text{Actual Linkages}}{\text{Possible Linkages}} = \frac{4}{10} = .4$

Key to Symbols
— - Link
★ - Clique Member

Figure 2-3

An example of high and low degrees of density within cliques.

The final category of communication structural properties is the individual. The important structural properties considered for individuals are communication roles, links, and density (Farace and Johnson, 1974). Communication roles can be broadly divided into participants and isolates, with participants further defined by clique members, bridges, liaisons, tree nodes, and others (Farace and Johnson, 1974). An isolate is defined as an individual in the network who has less than two communication links (Richards, 1975). A non-participant or an isolate in the network then is a person who has one or less communication interactions with other network participants. Richards (1975) describes a person with no communication links as an isolate type one. A person with only one link he describes as an isolate type two.

In reviewing the descriptions of participants, clique members have been defined previously as individuals who are more frequently in communication with other clique members than with non-clique members (Larkin, 1978). Rogers and Agarwala-Rogers (1976) describe liaisons as persons who interpersonally connect two or more cliques, but who do not belong to any clique. Persons who interpersonally connect two or more cliques, but who are members of a clique are labeled as bridges. A tree node is a person who is not a clique member, but connects a clique with an isolate type two. The communication roles of liaison, bridges, and tree nodes, which are called group linkers, are critical for network cohesion and information exchange because they control the rate and nature of information flow in the network (Albrecht, 1978). In the present study, the identification of the existence of group linkers can be an indication of the integration of a multidisciplinary network.

An individual who cannot be identified as an isolate, a group linker, or a clique member is simply referred to as an other (Richards, 1975). This individual may have two or more linkages which do not meet the requirements for clique membership or group linking.

The frequency of these roles in a communication network may vary according to Monge, Edwards, and Kirste (1978) with the communication content of the network. For example, Farace and Johnson (1974) found that the number of group linkers and isolates varied within the same system for networks of production, innovation, and maintenance.

The second structural property of individuals for review is the link, the most fundamental of structural properties (Rogers and Kincaid, 1981). A link indicates the communication relationship between network members (Larkin, 1978). Farace and Johnson (1978) report three characteristics of links often studied are the number of links for each member, the percentage of reciprocated dyads, and the strength of the links. Together, these characteristics provide an indication of the important linkages within the network.

Individual density, the last individual structural property presented, is the degree to which a member is linked to the network members (Rogers and Kincaid, 1981). This measure is defined as the actual number of links the individual has with other network members divided by the possible number of system links. The level of connectedness for an individual can provide a perspective of an individual member's integration with the network.

The concepts of network content and structural properties presented in this section provide an understanding of the communication relationships which can be identified in a communication network and how they can be applied to an investigation of behavior in a system. These concepts will provide the basis for the determination of multidisciplinary integration within the energy education personnel, the problem of the present study. The determination is possible because the existence of multidisciplinary integration can be graphically illustrated by placing content networks and cliques against the formal departmental structure.

Problem Hypotheses

This study seeks to determine multidisciplinary integration within the faculty involved in energy education at Michigan State University in 1981. The foundation for the study is from the work by Blau (1973) and Friedkin (1978), as well as, from network and network analysis concepts. Friedkin suggested that multidisciplinary integration may be fostered in a research setting. A suggestion which is contrary to Blau's postulation that multidisciplinary integration is unlikely. Friedkin's finding was from a study which focused on research communication in a research institution. Blau's conclusion was drawn from a study of general communication of faculty at a sample of American universities.

As the present study more nearly replicates Friedkin's problem and setting, the hypotheses for this study imply that multidisciplinary integration will be identified within the investigated population. To prove the existence of multidisciplinary integration, the first three hypotheses are related to the structural properties which will be sought by the communication network analysis of the personal involved in energy education. These hypotheses are intended to establish that the communication patterns existing between the energy education personnel comprise a network. The fourth and final hypothesis determines the multidisciplinary integration, the problem of the study.

The chapter's review of the literature presented selected research and writings regarding networks and network analysis. Networks were described as aggregates of individuals who have regular patterns of communication interaction. Network analysis was defined as a methodology for determining networks and their characteristics within a system.

Based on the network description, if multidisciplinary integration exists within a given set of faculty at a college setting, the faculty participants would in effect form a network

(Friedkin, 1978; Mulkay, Gilbert and Woolgar, 1975; and Mullins, 1972). For this reason, the present study's problem, the identification of multidisciplinary integration within the faculty and staff involved with energy education projects, can be investigated utilizing network concepts and network analysis procedures. The network analysis methodology which will be followed includes identifying the possible existence of a network of the energy education personnel. If the network exists, according to Richards (1975) and Rogers and Kincaid (1981), the participants in the network will have direct and indirect linkages with each other and each relationship will be based on regular communication concerning energy education. In addition, the network may have groupings of linkages composed of members who communicate more with each other than with other network members. These groupings are called cliques, if strict conditions are met by the members.

The first hypothesis is intended to establish the existence of regular communication patterns within the energy education personnel as a network.

H_1: The communication behavior of the involved personnel in energy education will be defined by the data analysis to have regular communication linkages.

The first hypothesis will be accepted if two conditions are met. First, the data analysis completed by the NEGOPY program must determine the individual communication relationships. In effect, the participants must indicate communication interaction on energy education with the other involved personnel. Second, the relationships must have at least the strength (or frequency of communication) of one hour per month (Richards, 1975).

In addition to the overall communication network, the sub-networks of specific communication content of production, innovation, and maintenance can be determined. These content networks will be noteworthy as to whether they exhibit multidisciplinary integration.

H_2: The data analysis of the communication content of the participants based on production, innovation, and maintenance will identify regular communication linkages for each content topic.

The acceptance of the second hypothesis is based on the same criteria used for the first hypothesis. The test of the second hypothesis is for the existence of the linkages. The second hypothesis will be accepted if communication linkages of at least one hour per month are identified within the communication behavior of the energy education personnel.

Sub-groups or cliques of relationships can be identified which have direct linkages to each other. These cliques can offer a more micro inspection of the composite relationships existing between members of a network.

H_3: The data analysis will identify cliques as a structural property of the network linkages.

The acceptance of the third hypothesis is based on Richards' (1975) definition of a clique. A grouping of linkages is considered a clique, according to Richards, if it is composed of three or more persons who have direct linkages to each other and have more than 50% of their links within the clique. In addition, no single link nor individual can be removed and cause the dissolution of the group. The NEGOPY program's algorithm can be set to determine cliques according to this definition.

The network linkages and cliques identified may be centered in academic departments or display communication patterns across departmental lines. In order to verify the existence of multidisciplinary integration, the linkages and the cliques must be constituted by persons from different academic departments.

H_4: Participation in the network linkages and the cliques will not be restricted by departmental membership.

Friedkin (1978) concluded multidisciplinary integration to exist in his study population based on the finding of 39% of the research relationships to be interdepartmental. The acceptance of the fourth hypothesis will be based on Friedkin's analysis. The fourth hypothesis will be accepted if at least 39% of the linkages are interdepartmental and at least 39% of the membership of any cliques is interdepartmental.

The network analysis procedures for identifying the communication content and structure were briefly mentioned in this chapter without conclusions made as to which techniques would be proper for the present study. The discussion of these procedures in the research methodology of this study is presented in Chapter III. The results of the data analysis and their implications for the study's hypotheses are reported in Chapter IV.

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study is to investigate for the existence of a multidisciplinary social network within the energy education personnel at Michigan State University in 1981. The presence of such a network would be unlikely according to Blau (1973), although a study by Friedkin (1978) has found a multidisciplinary network within a research setting. If the social network exists, the communication structure, and content of the network members will be analysed and discussed in relation to the previously noted research on multidisciplinary integration.

The existence of the social network and the nature of the members' communication content and structure was investigated by a communication network analysis. The analysis began with a survey of the study population's overall communication patterns related to energy education. From the survey data, the study population was identified and communication networks were constructed using NEGOPY (a statistical network analysis package). The networks determined by NEGOPY provided an identification of the communication content and structure, including the specific communication roles, linkages, and groupings existing within the projects' personnel. The results of the analysis are discussed in the context of Blau's (1973) postulation and Friedkin's (1978) finding on multidisciplinary social networks within academic settings.

Assumptions

In developing the methodology for this study, certain assumptions had to be made which were integral to the methodology's success. It was assumed that:

1. The Michigan State University energy education projects and their directors could be located and identified;
2. The project directors would consent to cooperate with the study;
3. The respondents would give honest replies on the questionnaire; and
4. The social structure of the study population would be stable enough to allow measurement.

Research Setting

The data were collected on the campus of Michigan State University between February 19 and March 24, 1981. The campus was active in the energy field with energy education projects primarily related to its land-grant heritage. Energy education projects which were reported included improving energy information for community decision-making, alternative energy techniques for grain drying, biomass from livestock waste, and Michigan tourism and energy.

It is important to note the campus climate at this time was unsettled, tense, and directed away from typical academic research and teaching due to current budget restrictions and further imposed program constrictions. Numerous respondents and non-respondents indicated difficulty in completing the study because of pressing budget matters.

Network Analysis Methodology

The objective of network analysis is to describe a system's communication structure (Rogers and Kincaid, 1981). This section presents the methodological procedures for collecting and analysing the data to describe the structure. Presented as well are the problems and strengths of these procedures and the reasons for selecting the procedures used in the present study.

Knoke and Kuklinski (1982) state that there are three matters which must be considered in any empirical research: boundary specifications, sampling, and measurement. The consideration of these three matters in a network analysis is influenced however by the nature of networks and the network analysis methodology. A description of these matters as they relate to network analysis is presented in the order of sampling, measurement, and boundary specification. Following these descriptions, a presentation of NEGOPY, the computer data analysis method, completes this section on network analysis methodology.

Sampling

Because network analysis studies interpersonal relationships and not individuals, sampling in a network analysis is of the entire study population whenever possible (Rogers and Kincaid, 1981). Each case of the study population is considered, otherwise the opportunity is lost for identifying relationships with other cases. Without a total population study, the network and its properties can be severly misrepresented by the absence of relationships which may play significant network roles. For this reason, random sampling is not appropriate for network analysis (Knoke and Kuklinski, 1982). Likewise, the application of conventional statistical procedures based on random sampling measures is not suitable for network analysis (Knoke and Kuklinski, 1982).

Measurement

Rogers and Kincaid (1981) cite the three main methods of measuring communication relationships to be observation, unobtrusive techniques, and survey sociometry. All of these methods have particular strengths which make each appropriate for different types of studies. In the observation method, the researcher monitors the behavior of a system and records the nature and frequency of the communication relationships as they occur. The strength of the observation method is that if the communication relationships are observed there can be little doubt about their validity. With survey methods, the population studied is asked to report their communication relationships. The respondents may jeopardize the validity of the data by not accurately reporting their behavior due to fatigue, misunderstanding, or other problems related to the survey process. The researcher however is trained to observe and to interpret behavior accurately and thus ensure a higher validity of measurement (Rogers and Kincaid, 1981).

One disadvantage of observation as a method of measurement is its practicality. To be successful, the observation method must be implemented in a small closed system. For example, Bernard and Killworth (1973 and 1978) have effectively used the method in prisons and on ships. In research problems such as the present study, with a study population widely separated, relatively large, and at least initially unknown, the technique is impractical and probably ineffective.

A second disadvantage of the observation method cited by Rogers and Kincaid (1981) is the obtrusiveness of the researcher in collecting the data. Because of the technique's nature and that it is most effective with a small closed study, the observer can become a part of the study (Bernard and Killworth, 1978). In cases where this involvement occurs, the obtrusiveness may well influence the behavior investigated.

The second method of measurement cited by Rogers and Kincaid (1981) is the unobtrusive method. In this approach, the observer is not directly involved with the behavior studied. Rather, records of events are studied in a historical fashion for relationships. The records can be tape recordings (Killworth and Bernard, 1976), legislative roll-calls (Stokman, 1977), and correspondence (Stern, 1979). From these records, relationships and roles can be identified and networks determined. Use of records has the advantage of providing the researcher with a view of the relationships over time for an analysis of change, as well as, greater data validity because of the unobtrusive approach. The problem with the approach however is that the data must be recorded and available for the researcher. These conditions are not always possible for most studies, including the current study.

The final method of measuring communication relationships is survey sociometry. Of the three methods cited by Rogers and Kincaid (1981), this method offers the most effective approach for collecting data in the present study. A researcher using the survey sociometry method gathers information about communication patterns of the system's individuals by asking them with whom they interact about a given topic. Depending on the nature of the study, the respondents may also be asked for the frequency of the contact and/or to indicate who are the most important contacts.

To encourage a greater identification of all relationships, a roster of the study population is frequently provided with the survey. The respondent can use the roster rather than memory to recall with whom they talk about a given topic. For this reason, the roster technique is beneficial for identifying the relationships which Granovetter (1973) calls "weak ties." Although these relationships are characterized by less frequent interaction, Granovetter has found weak ties to be critical for bridging communication flow between cliques of the networks. Without their inclusion in a network, the network properties could be misrepresented.

Because the roster technique facilitates the identification of weak ties, it is also one means of counteracting a criticism of sociometric surveys, the validity of self-reporting. Due to that the source of information is self-reports based on recall, serious questions have been raised about the sociometric data collection method. Based on their research, Bernard, Killworth, and Sailer (1981) feel that it is unrealistic to expect respondents to have perfect recall of their communications and to handle the amount of cognitive data requested in a sociometric survey. Burt and Bittner (1981) state, however, the conclusion of Bernard et al. is unwarranted. Burt and Bittner's counter argument is based on a re-analysis of the data used by Bernard et al. to reach their conclusion. Their assessment is that measurement by the sociometric procedure can be valid through a well conceived and conducted survey approach.

Erickson, Nosanchilk, and Lee (1981) plus Knoke and Kuklinski (1982) suggest that there are ways to minimize the respondent measurement error in a sociometric survey. The most effective way is to be as precise as possible with the respondents when defining the network content being solicited in the survey. The respondents should readily understand the survey and what is being asked of them for information. The roster technique as previously described is likewise an important means for aiding the respondents in completing the survey. Fatigue in reviewing the roster however can be a factor in respondent measurement error and must be considered when composing the survey instrument. Erickson et al. (1981) suggest that a roster of 130 can be safely used but as many as 200 may be too much for even the most willing respondent. Other suggestions for enhancing the survey are to pretest the survey, include the respondent's name in the roster list which he/she receives, and make a brief introductory statement in the respondents' own terms about the purpose of the study.

Boundary Specification

Knoke and Kuklinski (1982) regard boundary specifications as a difficult consideration for a communication network analysis. Boundary specification refers to the parameter limits set for collecting data. These limits are usually defined by the members of the studied entity. Consequently, only those persons who are relevant to the study are included within the boundaries.

Normally, the boundary specifications for many communication network analysis studies can readily be set if the problem is to study an intact unit's communication patterns. However, this approach is not practical in a large organization if the network members are unknown and the network to be identified has the potential to spread across the organization and include relatively few organization members. This situation exists in the present study where the energy education personnel and the extent of their spread across a major institution are not known at the time of the investigation.

In cases of unknown boundary specifications, Burt (1980) suggests identifying the boundary while sampling for data-collection using the "snowball sampling" technique. With this technique, persons who by their prominence are known to be members of the study population are used as an initial set of respondents. In a manner similar to the sociometric data collection procedure, these persons are surveyed for information not only on their communication patterns as related to the study topic but also for other persons with whom they have significant relationships within the study's criteria. The persons named in the data collection sampling are added to the list of respondents and they alone are surveyed in a second phase of data gathering. This technique can be repeated until a satisfactory study population is determined.

Burt (1980) indicates that the technique has been successfully used to identify networks of "elites" or specific types of persons within business corporations, academic disciplines, and neighborhood communities. Rogers and Kincaid (1981) also cite the technique's success in diffusion studies within neighborhoods and academic settings.

Rogers and Kincaid (1981) describe two disadvantages' of the snowball sampling technique if the sampling phases are not continued to a final phase where no new members are identified. First, individuals and small cliques who are not well connected to the prominent core set of respondents may be missed in the sampling process if the phases are not repeated enough. It is assumed that unless the clique or person is an isolate, the snowball sampling will eventually identify them. However, some less integrated network members may not be identified if the sampling phases terminate too soon to reach these members.

A second disadvantage is that the rate of reciprocation is affected. The study population added to the roster at the last phase will not have an opportunity to respond to the survey. For this reason, they cannot affirm the communication relationships between themselves and other study population members.

Related to Rogers and Kincaid's (1981) concern with the problem of sufficient number of sampling phases is the effect of time on a network (Knoke and Kuklinski, 1982). The question Knoke and

Kuklinski (1982) raise is how many phases are sufficient to reach all the appropriate study population members in light of any sociological considerations for the network under investigation? By conducting the survey over an extended period of time, there is a risk that the actual network itself may change by the final phase. Networks typically are not composed of a static set of communication relationships; network members do change as well as their relationships. Knoke and Kuklinski, as well as the literature, do not present any clear answer to this problem. The proper balance of the number of sampling phases and identifying all the possible population members is considered to be relative to each individual study situation.

Because the population of the present study is large, unknown, and spreads across a large system, the snowball sampling technique is the proper technique for data collection and for identifying the study sample. In sampling the population, however, there is not a need to identify all energy education personnel who are members of the network. If persons or small cliques are not located, the structural properties of the network will be affected but not the overall trend of the network relationships. Using the snowball sampling technique, the predominant members are identified and their relationships can be examined for multidisciplinary integration. Whether integration is found to exist or not, the persons and cliques not located by the sampling phases are either weak ties or isolates within the network because of their apparent low level of involvement with the predominant network members.

As all network members are not required for this study, the sampling phases was arbitrarily limited to two phases and set to not extend over a four-five week time span because of the potential change in projects and personnel on the energy education problem. If the sampling was to continue for a longer time period, the population sampled in the later phases would not be the same network which existed in the beginning of the study.

Analysing the Data

The purpose of the network analysis in the current study is to identify the communication content and structural properties of the population under investigation. These results are identified in the final research step, the data analysis. For the present study, the analysis of the data can be accomplished by any one of the previously indicated computer methods; however, NEGOPY will be the computer method used for the analysis.

The selection of NEGOPY as the computer method is based on its capability of providing the desired analysis for the research problem. Rogers and Kincaid (1981) describe NEGOPY as being preferable for research studies seeking to identify a large size study population's communication structure, particularly for networks, cliques, individual communication roles, and indices of connectedness. These dimensions of NEGOPY are essential for the successful implementation of the present study's methodology.

NEGOPY was invented by Richards (1975) in the mid-1970's in response to the need for a computer method to analyse large quantities of communication network data. The NEGOPY method analyses linkages among persons in large organizations for the purpose of identifying the communication structure at the individual, group, and network level. The properties of the communication structure which can be identified include the individual communication linkages and roles, the cliques and their linkages, and the degree of connectedness or density of the linkages (Rogers and Kincaid, 1981). In addition to the general communication structure, selected content of the communication shared by the network members can be analysed as separate communication structures. Each of these structures can then be compared to the formal organizational structure for similarities and differences (Farace, Monge, and Russell, 1977).

NEGOPY determines these communication structural properties from a data base of reported dyadic interaction frequencies. The study population is asked to indicate with whom they communicate about specific topics (i.e. identify their linkages) over a given time period. This data is entered into the computer and arrayed on an N x N matrix of respondents and their reported contacts. Using cluster analytic techniques, the data are decomposed and, based on each respondent's linkages, a communication position and role is assigned to each individual. From this analysis, cliques and networks can be constructed, as well as, the degree of density measured at the individual level and the clique level (Richards, 1975).

Because networks are based on the dyadic interaction frequencies, determining what constitutes a dyadic relationship or a link is an important consideration (Farace and Johnson, 1974) . In their review of research, Farace and Johnson (1974) have found that the determination of a dyad can vary between one person reporting the relationship, to a more stringent requirement of both persons reporting the relationship at the same frequency for the same content topics. However, intermediate definitions are found to be often used. For this study, reciprocated linkages are identified, but the network analysis is based on all relationships reported by the respondents, reciprocated or not. Reciprocated relationships were not required in the analysis because of the study's sampling technique and because valuable information would be lost otherwise. In this study, the snowball sampling was terminated after two phases. Those study population members identified in the second phase were not surveyed and given an opportunity to provide reciprocation responses. To not consider these unreciprocated relationships as well as others, from the earlier phase would be a loss of relevant network information. Support for this action is found in discussions on the topic by Alba and Kadushin (1976) and Rogers and Kincaid (1981). They feel that "forcing reciprocation" or considering all relationships as reciprocated is appropriate because persons do not always remember their relationships while completing the survey. In addition, relationships are sometimes not reported because of the status of the respondent or the respondent feels that the frequency of the relationship is too minimal to report.

Richards' (1975) NEGOPY method is distinctive in that it details an algorithm of mathematical and operational rules for identifying network properties like cliques, group linking roles, and connectedness or density. A brief description of how NEGOPY determines these properties will provide understanding of this analytical procedure. The NEGOPY method identifies a clique based on three or more individuals who have direct linkages to each other and have more than 50% of their links within the group. In addition, NEGOPY applies what Richards (1975) calls a critical criterion in determining a clique. The criterion is no single link must exist within the clique which if removed from the group, would cause the remaining clique members to not be able to meet the other criteria.

The group linking roles are identified by NEGOPY (Richards, 1975) as those persons who have linkages which connect two or more cliques. Their role is to facilitate communication flow between the cliques and for this reason are important to the functioning of the communication network (Guetzhow, 1965). Indeed, Schwartz and Jacobson (1977) have found group linkers to be the informational leaders for the network and to be considered by the network members as highly influential.

Connectedness or density refers to the degree to which individuals or cliques are related to each other respectively (Rogers and Kincaid, 1981). Friedkin (1981) describes connectedness as a measure of density or cohesion within the system. Such a measure indicates the amount of interaction which is taking place within the level of analysis. The degree of density is indexed by NEGOPY to the actual number of links which exist for the level of analysis, divided by the number of possible links for the level of analysis.

By using an algorithm for identifying these properties, NEGOPY has standardized network property meanings from study to study. In this way, researcher error and subjectivity are removed in identifying the communication structure's properties and content. For the present study, the standardization provides validity to any conclusions reached on the degree of multidisciplinary integration existing within the study population. NEGOPY's standardization also provides generalization of the study results, as well as, the data analysis to other similar campuses and studies.

Methodology in Relation to Purpose

The intent of this study was to investigate the existence of a social network of the energy education personnel at Michigan State University, how the network members were linked through communication, and the function of their communication. The investigation was accomplished using the procedures of communication network analysis. Communication network analysis is a research method developed out of sociometric techniques (Rogers and Kincaid, 1981). It takes a set of paired data which specify the interactions between individuals within a social environment and displays the interaction on a N by N person matrix (Taylor, 1976). NEGOPY, a computer based technique, was used to analyze these interactions among persons and within groups, and identify the communication roles, groupings, and functions in the system (Richards, 1975).

For this study, the participants of the survey population were asked to review a list of the names of people active in energy education at Michigan State University and record the number of hours they communicated with them in the functional areas of work (production), ideas (innovation), and personal (maintenance) in an average month during a normal academic term. The population was directed to leave blank the appropriate space next to any person listed with whom they did not normally communicate in any or all of the functional areas. If the participants did not find a person on the roster with whom they normally communicated, they were asked to include the person's name on the blank spaces at the end of the survey roster and to indicate the frequency of communication (see Appendix B).

The survey data were then entered in the NEGOPY program. The frequency parameters of the NEGOPY program were set to consider only those communication relationships with a minimum frequency of one hour and a maximum frequency of 255 hours per month. The reported contacts within the frequency parameters were compared against each other in a matrix to determine reciprocation of contact among respondents. To prepare the data for analysis, NEGOPY's statistical parameter forced reciprocation for any unreciprocated respondents. The data were then reduced through multivariate analytic techniques into network properties. The cliques (groups) were separated out and members were classified into one of the following role types: group member, isolate, or group linker (Albrecht, 1978).

The properties revealed by the network analysis procedures can be broken into three broad categories (Farace and Mabee, 1978): (1) properties of the network as a whole, including the size and, the connectedness of the structure, and the number and size of detectable cliques; (2) properties of groups or cliques, including number of members in each clique and the amount of structure binding the clique members; and (3) properties of the sub-networks associated with each individual node (person), including the role of the node in the network.

In addition to identifying the communication structure, a goal of the study was to identify the function of communication existing between the energy education personnel. This goal is important to the study because roles and groups may vary across "content networks" and provide an entirely different communication structure. A look at content networks may show that communication related to the energy education project directors' need for work or idea information may be flowing across the formal department lines. The analysis of the content networks may also indicate the importance of one or more of the communication functions to the social network's existence.

The content of communication was solicited from the participants by asking them to report their amount of communication in the functional areas of work, ideas, and personal with each of the individuals listed on the survey. The functional areas replicate Berlo's (1970) production, maintenance, and innovation categories. The titles were changed in the survey for the purpose of clarity and understanding. Appropriate clustering was completed on the content data in the same manner as the all-function communication network.

Study Population

The population studied was those full-time persons at Michigan State University who were involved with energy education projects in 1981. This population was selected because the purpose of the study was to investigate and identify the existence of a social network based on their communication structure and content. Only full-time faculty-staff were considered because of the temporary nature and lack of full campus involvement normally associated with part-time faculty-staff and graduate assistants.

An initial problem in studying the population was to identify the respective members. The members were not readily known because little knowledge existed in 1981 as to what was being done in energy education and by whom. In fact, Schriver (1979) described a problem which existed in coordinating the energy related projects and in avoiding a duplication of effort. The difficulty in coordinating the energy projects was due to the constant change of the energy projects, the lack of a formal means to identify who was doing what in the energy field at M.S.U., and the general autonomy of the departments at Michigan State University in conducting the projects.

This lack of knowledge of the energy projects conducted by the various University departments caused instances of duplication of effort. An example of this duplication was found "in Genesee County, at one point in time in late 1978 and early 1979, (where) there were no less than six different MSU energy projects conducting research or other activities" (Schriver, 1979). These activities were in some cases attempting to accomplish the same goals and to utilize the same resources. Eventually, the people in Genesee County affected by the projects raised a concern about MSU's lack of coordination and lack of knowledge of the projects.

A project in 1979 to identify all of the energy information services at MSU was a response to this problem. The project, conducted by the College of Education, attempted to contact all colleges and departments at Michigan State University which were active in the field of energy for descriptions of their energy programs. These descriptions were summarized and published in a directory entitled "Energy and the University: A Guide to Energy Programs and Resources at Michigan State University". However, the value of this directory in enhancing communication and integration of the departments' efforts is not known because a follow-up study did not occur.

The initial source to identify the population for this study was Schriver's 1979 directory. The second source was Mr. John Sarver, Michigan Department of Energy, who was contacted to ascertain the Michigan State University faculty and staff who were leaders of energy education projects funded by the Energy Department. Mr. Sarver served a coordinating role for the Energy Department with the Michigan State University energy projects which were funded by his department.

The names of the energy project directors were composited into a preliminary list which was reviewed by selected campus energy education personnel for additions, suggestions, and correction. The reviewers were Dr. Herman Koenig, Research and Graduate Studies; Dr. Jon Bartholic, Agricultural Experiment Station; Dr. William Cooper, Department of Zoology; Dr. Wally Piper, Student Activities Office; Mr. Tommy Mc Peak, Cooperative Extension; Dr. Thomas Edens, Agriculture Economics; and Dr. Bill Stout, Agriculture Engineering. These resource people were asked to review the preliminary list because of their high visibility and contacts in the energy education field at Michigan State University. The revised list was further refined through telephone calls to selected people on the list and to academic departments having energy projects. These latter contacts were also intended to build their commitment to complete the survey.

At this point, 126 persons had been identified as population study members. Although the list of energy education project directors was not considered to be complete, the communication network analysis (the survey) was initiated on this population. The reason for this step was that one of the first exercises in the analysis is to have the population being studied identify those energy education persons at Michigan State University with whom they are in frequent contact regarding energy education projects. Those persons identified who were not listed were added to the study population. From this first sampling phase, nineteen new members were included in the study for a total of 145. The revised survey was sent to these new population members in a second sampling phase and they were asked to participate with the analysis. In the second phase, seven new members were identified for a total of 152 in the study population. A third phase was not conducted.

The procedure used in identifying the population was based on the snowball sampling technique (Burt, 1980), as well as, Granovetter's (1976) work with social network sampling techniques. For this reason, it was assumed that by following their procedures a high percentage of the study population had been identified. Those persons not identified may either have been recent entries into the system or have had little visibility across campus. Further time and effort was not put into locating other possible energy education personnel because carrying the survey out over an extended period of time would have distorted the results. The communication network analysis is intended to be a tool for describing communication as it exists at a particular static time. If the study is over a prolonged period of time, persons will move in and out of the network and the structure and functions of communication will change.

Data Collection

Questionnaire

A questionnaire (see Appendix B) was administered to obtain the data on the communication patterns of those persons who were involved in an energy education project(s) at Michigan State University. The study population was limited to full-time personnel located on the East Lansing campus. The purpose of the questionnaire was to seek data which would identify:

1. the energy education projects at Michigan State University;
2. the goals and activities of the projects;
3. the population served by the projects;
4. who the participants communicate with on-campus regarding energy education;
5. the frequency of the communication contacts regarding energy education; and
6. the function served by the communication contacts.

The questionnaire was in two sections, a personal data sheet and the communication network analysis survey. The personal data sheet requested the study population members to provide information related to their campus position and energy education responsibilities. The data sheet was based on the 1979 questionnaire administered for the data found in "Energy and the University". Mac Donald's (1970) "personal contact checklist" and other selected communication network analysis surveys were the basis for the communication analysis. Selected on-campus energy education program directors were also contacted for their assistance in developing the questionnaire.

Before the questionnaire was administered, it was pretested with the same selected university energy education personnel who were asked to help identify the campus energy education personnel. This pretest was intended to: (1) identify any aspects of the questionnaire which were misleading, ambiguous, or unnecessary; and (2) evaluate data collection procedures.

The questionnaire and a return envelope was mailed to each of the project directors identified in the population. A cover letter (see Appendix B) explaining the purpose of the study was also included in the mailing. The participants were given a designated period of time by which to return the completed questionnaire. Follow-up written messages and telephone calls were made to those participants who did not return the questionnaire by the designated date. Of the 145 persons surveyed in the study, 102 usable surveys were returned for a response rate of 70%. The seven persons identified in the second phase were not surveyed.

The survey procedure was completed between February 19 and March 24, 1981. Approximately five weeks was given to the survey because new names for the study population were generated by the initial communication network analysis and time was needed to contact and survey them with a second sampling questionnaire. As previously mentioned, the survey process was not extended beyond five weeks and two phases because of the changing dynamics of communication networks and the high percentage of energy education members felt to have been identified in the two phases.

The results of the analysis of the data collected through the survey questionnaire and their relationship to the study hypotheses are presented in Chapter IV.

CHAPTER IV

ANALYSIS OF THE DATA AND RESULTS

Introduction

The intent of the present study is to test Blau's (1973) postulation that multidisciplinary integration is unlikely within university and college institutions against Friedkin's (1978) finding that multidisciplinary integration may be possible in certain academic research settings. The study is being investigated by conducting a communication network analysis of the personnel involved with energy education projects at Michigan State University in 1981. The analysis will identify the possible existence of a communication network within the study population. The presence of such a network will indicate multidisciplinary integration in this academic setting.

The first section of Chapter IV describes the study population.The results of the communication network analysis for the study is presented in the second section of the chapter. The analysis was accomplished by using the NEGOPY computer program developed by William Richards (1975). The analysis identified communication networks from the content of the surveyed population's communication as related to energy education. The specific content of energy education communication sought was based on Berlo's (1970) three functions of communication: production, maintenance, and innovation. The final section of the chapter reports the evaluations for the hypotheses based on the data analysis.

Table 4-1.

Members of the Energy Education Study Population.

Name	Department	College/Division/Program
Abkin	Agricultural Economics	Agriculture and Natural Resources
Allen	Social Science	Social Science
Andrews	Family and Child Ecology	Human Ecology
Anderson	Continuing Education	Education
Arntzen	Plant Research Lab	Natural Science
Asmussen	Electrical Engineering	Engineering
Bakker-Arkema	Agricultural Engineering	Agriculture and Natural Resources
Bandurski	Botany and Plant Pathology	Natural Science
Bartholic	Agricultural Experiment Station	Agriculture and Natural Resources
Bird	Entomology	Natural Science
Black	Agricultural Economics	Agriculture and Natural Resources
Boger	Family and Child Ecology	Human Ecology
Boling	Zoology	Natural Science
Borgstrom	Food Science	Agriculture and Natural Resources
Bowman	Administration and Higher Education	Education
Brandon	Dean's Office	Natural Science
Brook	Agricultural Engineering	Agriculture and Natural Resources
Brown	Agricultural Engineering	Agriculture and Natural Resources
Cantlon	Research and Graduate Studies	Graduate Studies
A. Carroll	Cooperative Extension	Agriculture and Natural Resources
T. Carroll	Social Science Research Bureau	Social Science
Case	Human Environment and Design	Human Ecology
Chappelle	Forestry	Agriculture and Natural Resources
Connor	Agricultural Economics	Agriculture and Natural Resources
Cooper	Zoology	Natural Science
Crawford	Agricultural Economics	Agriculture and Natural Resources
Crawley	Physics	Natural Science
Cron	Agricultural Engineering	Agriculture and Natural Resources

Dahl	Food Science	Human Ecology
Dickerson	Museum	Graduate Studies
Dickman	Forestry	Agriculture and Natural Resources
Donakowski	Dean's Office	Arts and Letters
Dwyer	Anthropology	Social Science
Eastman	Civil Engineering	Engineering
Edens	Entomology	Agriculture and Natural Resources
Edwards	Agricultural Engineering	Agriculture and Natural Resources
Erickson	Crop and Soil Science	Agriculture and Natural Resources
Esmay	Agricultural Engineering	Agriculture and Natural Resources
Farace	Communication	Communication Arts and Sciences
Field	Family and Child Ecology	Human Ecology
Filner	Biochemistry	Natural Science
Fink	Metallurgy, Mechanics and Materials Science	Engineering
C. Fridgen	Human Environment and Design	Human Ecology
J. Fridgen	Park and Recreation Resources	Agriculture and Natural Resources
Gage	Entomology	Natural Science
Gallagher	Science and Mathmatics Teaching Center	Education
Geasler	Cooperative Extension	Agriculture and Natural Resources
Gerrish	Agricultural Engineering	Agriculture and Natural Resources
Gladhart	Family and Child Ecology	Human Ecology
Good	Botany and Plant Pathology	Natural Science
Goodman	Electrical Engineering	Engineering
Grulke	Chemical Engineering	Engineering
Haarer	Land Mangement	Agriculture and Natural Resources
Hall	Agricultural Engineering	Agriculture and Natural Resources
Hamlin	Urban Planning and Landscape Architecture	Social Science
Hanover	Forestry	Agriculture and Natural Resources
Harris	Sociology	Social Science
Hart	Forestry	Agriculture and Natural Resources
Hathaway	Family and Child Ecology	Human Ecology
Hawley	Chemical Engineering	Engineering
D. Haynes	Entomology	Natural Science
S. Haynes	Physics	Natural Science
Heldman	Food Science	Agriculture and Natural Resources
Helsel	Crop and Soil Science	Agriculture and Natural Resources
Hetherington	Science and Mathematics Teaching Center	Natural Science
Hinojosa	Urban Planning and Landscape Architecture	Social Science
Holecek	Park and Recreation Resources	Agriculture and Natural Resources

Hollingsworth	Dean's Office	Arts and Letters
H. Huber	Forestry	Agriculture and Natural Resources
J. Huber	Animal Science	Agriculture and Natural Resources
Hudson	Center for Remote Sensing	Agriculture and Natural Resources
Kakela	Resource Development	Agriculture and Natural Resources
Keefe	Family and Child Ecology	Human Ecology
Keith	Family and Child Ecology	Human Ecology
Kempton	Family and Child Ecology	Human Ecology
Kerber	Engineering Research	Engineering
Koenig	Research and Graduate Studies	Graduate Studies
Kolasa	Food Science	Human Ecology
Krauss	Engineering Research	Engineering
Lambeth	Urban Planning and Landscape Architecture	Social Science
Lamore	Urban Affairs	Urban Development
Lamport	Plant Research Lab	Natural Science
Landes	Science and Mathematics Teaching Center	Education
Levine	Psychology	Social Science
Libby	Agricultural Economics	Agriculture and Natural Resources
Loudon	Agricultural Engineering	Agriculture and Natural Resources
Mack	Agricultural Engineering	Agriculture and Natural Resources
McDonough	Park and Recreation Resources	Agriculture and Natural Resources
McLary	Natural Science	Natural Science
McLeod	Science and Mathematics Teaching Center	Natural Science
McPeak	Cooperative Extension	Agriculture and Natural Resources
Mill	Park and Recreation Resources	Agriculture and Natural Resources
Molder	Agricultural Experiment Station	Agriculture and Natural Resources
Moncrief	Park and Recreation Resources	Agriculture and Natural Resources
Montgomery	Mechanical Engineering	Engineering
Mooney	Honors College	Honors College
B. Morrison	Family and Child Ecology	Human Ecology
D. Morrison	Sociology	Social Science
Murphy	Botany and Plant Pathology	Natural Science
Muth	Administration and Higher Education	Education
Neff	Cooperative Extension	Human Ecology
Neumann	Cooperative Extension	Agriculture and Natural Resources
Niehoff	International Studies and Programs	International Studies and Programs
Nygren	Human Environment and Design	Human Ecology
Orlick	Urban Planning and Landscape Architecture	Social Science
Park	Electrical Engineering	Engineering

Parsch	Agricultural Economics	Agriculture and Natural Resources
Person	Agricultural Engineering	Agriculture and Natural Resources
Pigozzi	Geography	Natural Science
Piper	Student Activities	Student Affairs and Services
Ramm	Forestry	Agriculture and Natural Resources
Reddy	Microbiology	Natural Science
Reusch	Chemistry	Natural Science
Rippen	Food Service	Human Ecology
Robison	Agricultural Economics	Agriculture and Natural Resources
Rogers	Physics	Natural Science
Rosenberg	Mechanical Engineering	Engineering
Rothert	Cooperative Extension	Agriculture and Natural Resources
Rotz	Agricultural Engineering	Agriculture and Natural Resources
Schick	Resource Development	Agriculture and Natural Resources
Schultick	Resource Development	Agriculture and Natural Resources
Schwab	Agricultural Economics	Agriculture and Natural Resources
Shaffer	Agricultural Economics	Agriculture and Natural Resources
Snow	Lyman Briggs	Lyman Briggs
Sommers	Geography	Social Science
Srivastava	Agricultural Engineering	Agriculture and Natural Resources
Steffe	Agricultural Engineering	Agriculture and Natural Resources
Steinmueller	Resource Development	Agriculture and Natural Resources
Stout	Agricultural Engineering	Agriculture and Natural Resources
Stowe	Human Environment and Design	Human Ecology
Stynes	Park and Recreation Resources	Agriculture and Natural Resources
Suchsland	Forestry	Agriculture and Natural Resources
Suter	Metallurgy, Mechanics and Materials Science	Engineering
Thomas	Dairy Science	Agriculture and Natural Resources
Tolbert	Biochemistry	Agriculture and Natural Resources
Tombaugh	Forestry	Agriculture and Natural Resources
Tummala	Electrical Engineering	Engineering
VanEe	Agricultural Engineering	Agriculture and Natural Resources
VanRavensway	Agricultural Economics	Agriculture and Natural Resources
Veenstra	Zoology	Natural Science
Vitosh	Crop and Soil Science	Agriculture and Natural Resources
VonTersch	Dean's Office	Engineering
Waller	Animal Science	Agriculture and Natural Resources
Warback	Urban Planning and Landscape Architecture	Social Science
Wilkinson	Chemical Engineering	Engineering

Wittwer	Agricultural Experiment Station	Agriculture and Natural Resources
Wood	Agriculture Economics	Agriculture and Natural Resources
Woodruff	Physics	Natural Science
Wright	Lyman Briggs	Lyman Briggs
Yokoyama	Animal Science	Agriculture and Natural Resources
Zapp	Electrical Engineering	Engineering
Zuiches	Sociology	Social Science

Table 4-2.

Departments Represented in the Study Population.

Department	# Of Members
Administration and Higher Education	2
Agricultural Economics	11
Agricultural Engineering	16
Agricultural Experiement Station	3
Animal Science	4
Anthropology	1
Biochemistry	2
Botany and Plant Pathology	3
Center for Remote Sensing	1
Chemical Engineering	3
Chemistry	1
Civil and Sanitary Engineering	1
Communication	1
Cooperative Extension Service	6
Continuing Education	1
Crop and Soil Sciences	3
Dairy Science	1
Deans Office (Arts and Letters)	2
Deans Office (Engineering)	1
Deans Office (Natural Science)	1
Electrical Engineering and Systems Science	5
Engineering Research	2
Entomology	4
Family and Child Ecology	9
Food Science and Human Nutrition	5
Forestry	7
Geography	2
Honors College	1
Human Environment and Design	3
International Studies and Programs	2
Land Management	1
Mechanical Engineering	2
Metallurgy, Mechanics and Materials Science	2
Microbiology and Public Health	1
Museum	1
Natural Science	1
Park and Recreation Resources	6
Plant Research Lab	2
Physics	4
Psychology	1
Research Development and Graduate Studies	2
Resource Development	4
Science and Mathematics Teaching Center	4
Social Science	1
Social Science Research Bureau	1
Sociology	3
Student Activities	1
Urban Affairs	1
Urban Planning and Landscape Architecture	5
Zoology	3
Lyman Briggs	2

Table 4-3.

Colleges, Divisions, and Programs Represented in the Study Population.

College/Division/Program	# of Members
Agriculture and Natural Resources	64
Arts and Letters	3
Communication Arts and Sciences	1
Education	6
Engineering	16
Honors	1
Human Ecology	17
International Studies and Programs	2
Lyman Briggs	2
Life Long Education	1
Natural Science	22
Research and Graduate Studies	3
Social Science	12
Student Affairs and Services	1
Urban Development	1

Table 4-4.

Study Population's Reported Type of Involvement in Energy Education Activities.

Involvement Type	# of Members
Research Only	31
Research and Public Service	16
Research and Teaching	15
Public Service	13
Research, Public Service, and Teaching	12
Teaching Only	6
Teaching and Public Service	2

(Note: Seven of the respondents did not indicate their type of energy education involvement activity.)

Description of the Study Population

The snowball sampling technique was used to identify the study population of full time faculty and staff who were involved with energy education projects at Michigan State University in the spring of 1981. Through this technique, 152 participants were found in the energy education population (see Table 4-1). The participants were from 51 University departments representing 15 colleges, divisions and programs on campus (see Tables 4-2 and 4-3). The Departments of Agricultural Engineering and Agricultural Economics had the largest number of members with 16 and 11 respectively. Nineteen other departments had only one member in the study population. Of the colleges, the College of Agriculture and Natural Resources and the College of Natural Sciences had the greatest participation with 64 and 22 members respectively. The Colleges of Communication Arts and Sciences, Urban Development, and Honors had only one member in the study.

Research was reported to be the primary involvement of the study population in energy education (see Table 4-4). Nearly thirty percent of the respondents (31) indicated their involvement to be solely research. An additional forty-two percent of the respondents (43) indicated their involvement to be research with teaching and/or public service. The next greatest activity was in public service with 12 percent of the respondents (13) indicating their only involvement in energy education to be public service.

The energy education projects described by the participants were numerous and varied. The projects were intended to service such publics as the general citizenry, farmers, other scientific

TABLE 4-5.

Comparison of Network Properties By Communication Function.

	All-Function Content	Production Content	Innovation Content	Maintenance Content
Network Values				
Number of Links	1,683	1,683	1,446	754
Interdepartmental Links	1,292	1,292	1,105	457
Intradepartmental Links	391	391	341	297
Number of Members	152	152	152	152
Range of Strength	1-90	1-90	1-50	1-30
Mean Strength of All Links	2.95	2.95	2.3	2.4
Percent of Reciprocated Links	25.3%	25.3%	23.1%	16.8%
Communication Roles				
Dyads	none	none	1	none
Isolate Type One	9	9	9	21
Isolate Type Two	14	14	10	27
Tree Nodes	none	none	none	2
Liaisons	none	none	none	4
Bridges	31	31	none	none
Cliques				
Group #1				
Size	121	121	131	7
Number of Links	-	-	-	14
Interdepartmental Links	-	-	-	8
Intradepartmental Links	-	-	-	6
Density	-	-	-	.3
Percent of Reciprocation	-	-	-	32.4%
Average Strength of All Group Links	-	-	-	4.6
Average Strength of Within Group Links	-	-	-	7.7
Average Strength of Between Group Links	-	-	-	1.9
Composition	Forty-two of the fifty-one departments found in the study have members in this group. Ten colleges, divisions and programs are also represented.	Forty-two of the fifty-one departments found in the study have members in this group. Ten colleges, divisions and programs are also represented.	Forty-six of the fifty-one departments found in the study have members in this group. Thirteen colleges, divisions and programs are also represented.	The group is composed of members from four different departments.

Group #2			
Size	5	5	19
Number of Links	14	14	66
Interdepartmental Links	2	2	42
Intradepartmental Links	12	12	24
Density	.70	.70	.19
Percent of Reciprocation	33.33%	33.33%	15.18%
Average Strength of All Group Links	4.1	4.1	2.7
Average Strength of Within Group Links	10.6	10.6	3.7
Average Strength of Between Group Links	.47	.47	1.3
Composition	Four of the clique members are from the Department of Park and Recreation Resources. The fifth member is from the Department of Urban Planning and Landscape Architecture.	Four of the clique members are from the Department of Park and Recreation Resources. The fifth member is from the Department of Urban Planning and Landscape Architecture.	The group is composed of thirteen faculty from five departments within the College of Agriculture and Natural Resources; four faculty from three departments within the College of Social Science; and two faculty from two departments within the College of Human Ecology.
Group #3			
Size			4
Number of Links (All Intradepartmental)			12
Density			1.0
Percent of Reciprocation			20.0%
Average Strength of All Group Links			6.1
Average Strength of Within Group Links			9.1
Average Strength of Between Group Links			.9
Composition			The group is composed of faculty within the Science and Mathematics Teaching Center.

Group #4	
Size	15
Number of Links	140
Interdepartmental Links	10
Intradepartmental Links	130
Density	.67
Percent of Reciprocation	27.9%
Average Strength of All Group Links	1.6
Average Strength of Within Group Links	1.7
Average Strength of Between Group Links	1.2
Composition	The group is comprized of fourteen members of the Agricultural Engineering Department and one member of of the Food Science Department.

Group #5	
Size	3
Number of Links (All Interdepartmental)	2
Density	.67
Percent of Reciprocation	0.0%
Average Strength of All Group Links	-
Average Strength of Within Group Links	-
Average Strength of Between Group Links	-
Composition	The three members are from three different departments within the College of Engineering.

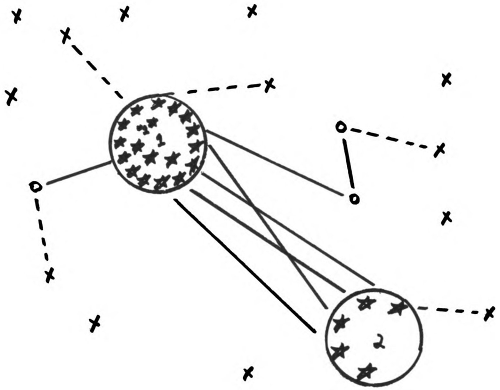
researchers, public agencies, and private corporations. The projects mentioned included solar water heating systems, wind energy, methane gas production from manure, energy education curriculum development, utilization of waste heat, the relationship of construction and landscape material to energy use, improving energy information for community decision-making, and energy audit systems for homes and buildings.

Analysis of the Communication Relationships

In analysing the communication relationships described by the study population respondents, the NEGOPY program found communication networks for each of the three separate communication functions, as well as, for all-function communication (the three communication functions considered together). The analysis identified the network values, linkages, and the cliques including size, properties, and composition for each of the four network structures (see Table 4-5).

The reader is again reminded of the glossary of terms which is located in Appendix A. The glossary can be of assistance in better understanding the structural values determined by the analysis. Definitions are also given within the text where appropriate.

The all-function content network and the production content network were found by the network analysis to have the same structural values (see Figure 4-1). Both networks were composed of 152 members with 1,683 links or relationships. Of the 1,683 links, 1,292 (77%) were of interdepartmental relationships and 391 (23%) were of intradepartmental relationships. The percent of reciprocated relationships was 25.3% for each network. This property means that approximately a fourth of the reported relationships were in agreement by each party. The range of the strength or frequency for all of the relationship's within each network was from one hour to 90



Key to Symbols
O - Clique
★ - Clique Member
—— - Clique Link
x - Isolate
--- x - Isolate Link
• - Other

Figure 4-1.

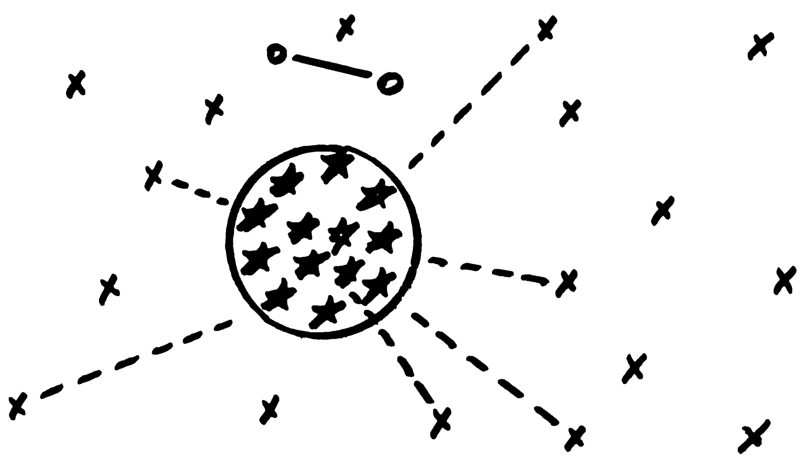
Figure representing the energy education networks for production content and for all-function content.

hours per month with a mean strength of 2.95 hours per month.

The communication roles for the members of each network did not include dyads, liaisons, or tree nodes. There were, however, thirty-one bridge links, nine isolate type ones, fourteen isolate type two's, and four others. Of the 31 bridge links, 22 of them involve individuals from the College of Agriculture and Natural Resources. The nine isolate type ones (individuals with no communication links) are all from different academic departments. However, five of the nine departments are within the College of Natural Science. The majority of the isolate type two's have links to group members from Agricultural Economics and Botany and Plant Pathology. Two of the four others are from the Dean's Office, College of Arts and Letters.

The network analysis identified two distinct cliques within each of the two networks. As noted before regarding the two networks having the same structural values, the cliques in the all-function network are identical to the cliques in the production network. Because of the size of the first clique, the NEGOPY program could not perform an analysis for density, percent of reciprocation, and number of links. Although the clique is unusually large, the group met the criteria for a clique in that each group member has direct linkages to each other member, the clique is composed of more than two members, and 50% or more of each member's links are within the group. For this reason, the NEGOPY program could not break the group down into smaller cliques for further analysis of relationships and meet the given criteria for being a clique. The group is composed of 121 members from 42 of the 51 departments represented by the study population. The College of Agricultural and Natural Resources has the largest number of members with 60, followed by the College of Natural Science with sixteen and the College of Engineering with fourteen.

The second clique within the two networks is composed of five members, four from the Department of Park and Recreation Resources and one from the Department of Urban Planning and Landscape Architecture. Each group has 14 links with a density of .70. Of the fourteen links within the clique, two of the links were interdepartmental and twelve were intradepartmental links. The percent of reciprocation is 33.33%. The average strength is 10.6 for within group links and 4.7 for links between group members and network members outside the clique. The average strength for all group links is 4.1.



Key to Symbols
- O - Clique
- ★ - Clique Members
- ✗ - Isolate
- o—o - Isolated Dyad
- - - - ✗ - Isolate Link

Figure 4-2.

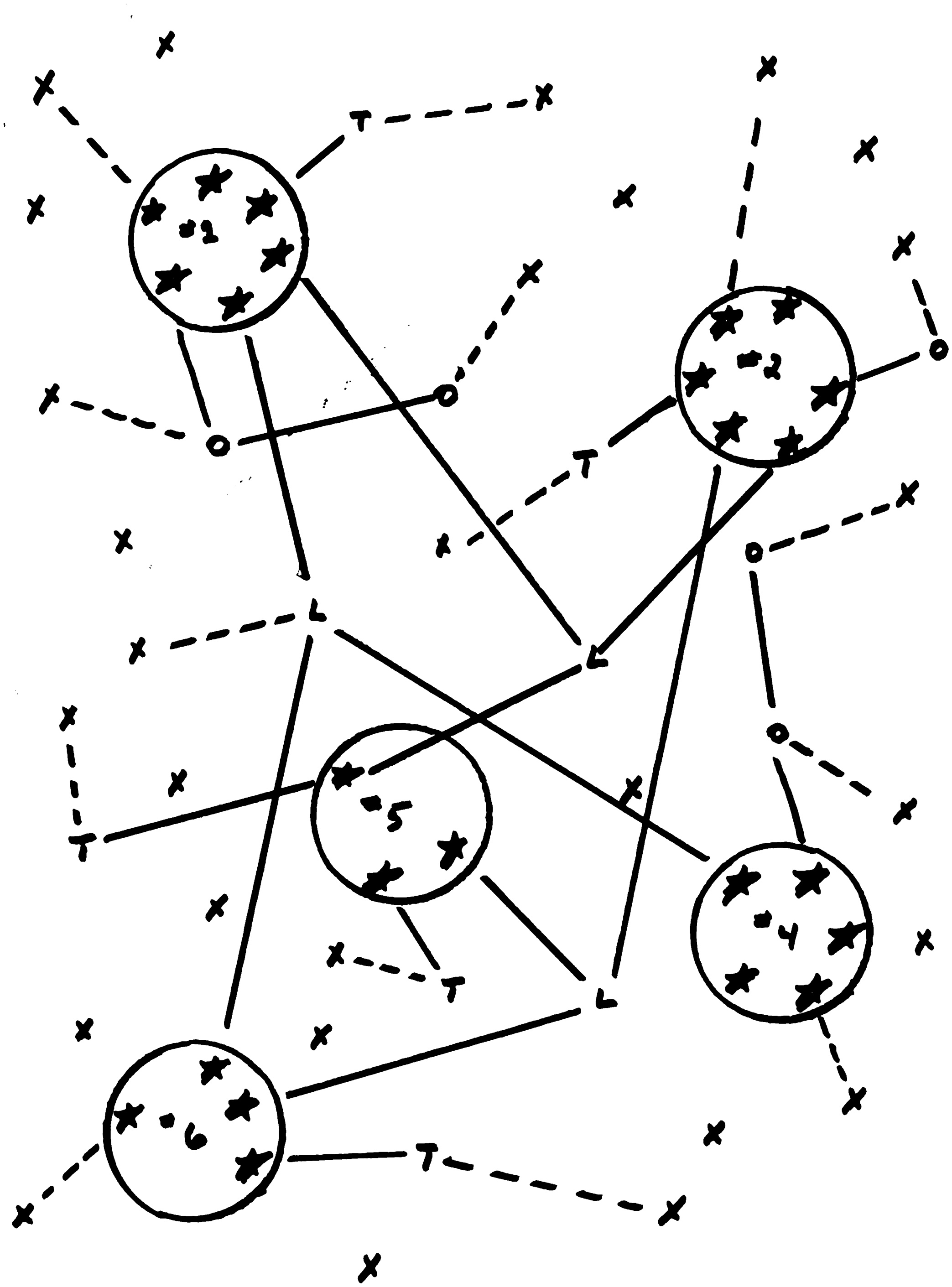
Figure representing the energy education network for innovation content.

The third network, the innovation content network (see Table 5 and Figure 4-2), is composed of 152 members with 1,446 links. The percent of reciprocated links is 23.1%. Interdepartmental relationships comprised 1,105 (76%) of the 1,446 links and intradepartmental relationships comprised 341 (24%) of the links. The range of strength for the links is from 1 hour to 50 hours per month with a mean strength for all links of 2.3.

The communication roles for the innovation content network do not include group linkers as there is just one clique in the network. There are, however, within the network one dyad, nine isolate type ones, and ten isolate type two's with links to group members from ten different departments. Seven of the network members who are isolate type two's were also isolate type two's in the two previously described networks. However, three of the seven's group links are different in the innovation network.

The dyad is composed of two members of the Urban Planning and Landscape Architecture Department. The nine isolate type ones are from eight different departments with the College of Natural Science having five of the nine isolates. The Physics Department has two of the isolates. In comparing the nine isolate type ones in this network to the nine isolate type ones in the all-function content network and the production content network, it is found that six of these individuals are isolate type ones in all three networks.

The only clique for the network is composed of 131 members from forty-six of the fifty-one departments represented by the study population. The College of Agricultural and Natural Resources has 62 members in the clique. In addition, the College of Natural Sciences has 16 members; the College of Human Ecology has 15 members; and the College of Engineering 14 members. Again, because of the large clique size, the NEGOPY program could not perform an analysis for density,



Key to Symbols
- Clique
- Clique Member
- Clique Link
- Liaison
- Isolate
- Isolate Link
- Other
- Tree Node

Figure 4-3.

Figure representing the energy education network for maintenance content.

number of links, and percent of reciprocation. As with the first clique in the all-function network and the production network, the group met the criteria for being a clique and could not be broken down into smaller cliques which could have been further analysed.

The final network, the maintenance content network (see Table 4-5 and Figure 4-3), presents a wide variety of communication network properties. The network is composed of 152 members with 754 links. Of the 754 links, 457 (61%) are interdepartmental relationships and 297 (39%) are intradepartmental relationships. The range of strength for the links is from 1 hour to 30 hours per month with a mean strength for all links of 2.4 hours per month. The percent of reciprocated links is 16.8%. The communication roles identified within the network include 27 isolate type two's, 21 isolate type ones, two tree nodes, 50 others, and four liaisons from four different departments.

The 27 isolate type two's represent 25 different departments. The Departments of Agricultural Economics and Family and Child Ecology have two members each who are isolate type two's in this network. In addition, three of these isolate type two's are found in all four networks. Only one of the isolates maintained the single link to the same group member in all four networks.

The twenty-one isolate type ones are from eighteen different departments. The Department of Physics, Botany and Plant Pathology, and Family and Child Ecology have two members each who are isolate type ones in this network. The College of Natural Science has eight of the twenty-one isolate type ones. Four persons were isolate type ones in all four networks.

One of the tree nodes, a member of the College of Agriculture and Natural Resources, links with a member of his department to another member from a different department in the same college who is an isolate type two. The second tree node, a member of the College of Human Ecology, links with a member of the College of Agriculture and Natural Resources to another College of Human Ecology member (in the same department as the tree node) who is in isolate type two.

As evidenced by the high number of linking roles, the network has five cliques. The first clique has seven members with 14 links and a density of .33. Interdepartmental relationships comprise 8 (57%) of the links and 6 (43%) are intradepartmental relationships. The percent of reciprocation is 32.4%. The average strength of links is 4.6 hours per month, with 7.7 as the average strength of links within the group, and 1.9 as the average strength for links between group members and outside group members. The clique is composed of one member from the Office of Student Activities, two from the Department of Zoology, three from the Department of Entomology, and one from the Department of Higher Education Administration.

The second clique is the largest with nineteen members and sixty-six links, but it has the lowest density of .19 and the lowest percent of reciprocation at 15.18%. The sixty-six links are split between 42 (64%) interdepartmental relationships and 24 (36%) interdepartmental relationships. The average strength of all group links for the clique is 2.7 hours per month, with 3.7 as the average strength of links within the group, and 1.3 the average strength of links between group members and outside group members. The clique is composed of thirteen faculty from five departments within the College of Agricultural and Natural Resources; four faculty from three departments within the College of Social Science; and two faculty from two departments within the College of Human Ecology.

The third clique has the second lowest number of members with four and a perfect density of 1.0. The group has 12 links and a percent of reciprocation of 20.0. The average strength of all group links is 6.1 hours per month, with an average strength of 9.1 for the within group links, and .9 for the links between group members and outside group members. The group is composed entirely of faculty from the Science and Mathematics Teaching Center.

Two departments from the College of Agricultural and Natural Resources comprise the fourth clique which is the second largest with fifteen members and 140 links. Interdepartmental relationships comprise 10 (7%) of the links and 130 (93%) are intradepartmental relationships. Fourteen members are from Agricultural Engineering and one is from Food Science. The group has a density of .67 and a percent of reciprocation of 27.9%. The average strength of all group links is 1.6 hours per month, with 1.7 the average strength for within group links, and 1.2 for links between group members and outside group members.

The final clique is the smallest group with three members and two links. They are from three departments within the Engineering College. The density for the group is .67 and the percent of reciprocation is 0.0%.

Hypotheses

H_1: The communication behavior of the involved personnel in energy education will be defined by the network analysis to have regular communication relationships.

This hypothesis states that regular communication patterns exist within the energy education personnel. For such patterns to exist, regular communication concerning energy education must be found between the participants and each participant must have direct and indirect linkages with the other participants at least the strength of one hour per month. Based on the analysis of the data completed by the NEGOPY computer program, linkages do exist for the energy education personnel. Following the criteria, a network of all-function content related to energy education was identified composed of the 152 members in the study population with 1,692 linkages. The first hypothesis is supported by the data analysis.

H_2: The analysis of the communication content of the participants based on production, innovation, and maintenance will identify regular communication linkages for each content type.

The second hypothesis asserts that linkages based on the specific energy education communication content of production, innovation, and maintenance are present within the study population. The criteria for the existence of these networks are identical to the all-function content network (i.e. regular communication between the personnel on these sub-topics and direct and indirect linkages.). These content specific networks were identified by NEGOPY's analysis of the data. A network composed of the 152 members in the study population was determined for each of the function contents of production, innovation, and maintenance with 1,692, 1,452 and 764 linkages for each respective sub-topic. The second hypothesis is supported as well by the data analysis.

H_3: The data analysis will identify cliques of communication linkages.

This hypothesis states that cliques exist within the network. Such cliques as defined by Richards (1975) must be composed of three or more members who have direct linkages to each other and who have more than 50% of their links within the clique. In addition, no link nor member may be removed from the clique which would cause the grouping to not meet the criteria. The NEGOPY's analysis of the data which was pre-set to this criteria did determine ten cliques within the networks. The cliques varied in size, number, and density per content network (see Table 4-5). The data analysis supports the hypothesis.

H_4: Participation in the linkages and the cliques will not be restricted by departmental membership.

This hypothesis states the existence of multidisciplinary integration within the energy education personnel. In testing this statement, the data analysis found all 152 members of the study population to be in each of the four content networks. In addition, the study population was from 51 university departments (see Tables 2 and 3). As network participants, all of the population members had communication access to each other either directly or indirectly across departmental structures. Indeed, within both the all-function network and the production network, 1,292 (77%) of the 1,683 linkages were interdepartmental relationships. The networks for innovation and maintenance had interdepartmental linkages of 1,105 (76%) and 457 (61%) respectively.

In reviewing the cliques for restriction by departmental membership, the greatest evidence of interdepartmental behavior is found in the cliques of the all-function, production, and innovation networks; the networks most directly related to energy education. The three major cliques of these networks were respectively composed of 121 (all-function), 121 (production), and 131 (innovation) members from over 80% of the 51 departments in the study. Because of the size of the cliques, the interdepartmental and intradepartmental linkages can not be calculated by the NEGOPY program. Due to the number of departments represented in the cliques and the strong percentage of interdepartmental linkages found in the overall networks, the majority of the clique linkages would be expected to be interdepartmental. The small cliques in the all-function network and production network had representation from two departments. The linkages for these cliques however were primarily intradepartmental because four of the five members were from the same department.

In addition, only one of the ten cliques identified by the data analysis within the four networks was composed entirely of members from one department. This clique was in the maintenance network and was composed of four members. The remaining nine cliques were composed of members from two or more departments. The percentage of interdepartmental linkages for the six cliques which are calculable were 29%, 29%, 57%, 64%, 7%, and 100%. Friedkin found multidisciplinary integration to exist with interdepartmental linkages of 39%. Using his criteria as a test and in view of the other results noted, the hypothesis is supported by the data analysis. Membership in the network linkages and cliques was not restricted by departmental membership.

Chapter V presents conclusions based on an interpretation of the data analysis and results in relation to Blau's postulation and Friedkin's findings. The chapter concludes the report of the study with suggestions for future research.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDED RESEARCH

Introduction

The purpose of this study was to determine the existence of multidisciplinary integration within the personnel involved with the energy education projects at Michigan State University in 1981. The study extended Friedkin's (1979) finding of multidisciplinary integration in a research setting against Blau's postulation that such integration is unlikely in academic settings. The literature review supported the use of communication network concepts and analysis procedures in establishing the study hypotheses and the investigation methodology. The results of the data analysis indicated the existence of an integrated network of multidisciplinary energy education personnel. The conclusions of the study and recommended future research are presented in this final chapter.

Conclusions

Several conclusions may be drawn from the results of the study. First, the determination of the multidisciplinary social network within the energy education personnel supports Friedkin's suggestion that multidisciplinary integration can occur, particularly in a research setting. This is a conclusion which is contradictory with Blau's postulation that such integration is unlikely in the college and university setting.

The identification of multidisciplinary integration in this study builds a broader foundation that a collegial atmosphere does exist in the pursuit of academic research. Academic specialization and departmentalization are not necessarily impediments to interdepartmental collaboration within research settings. The concerns cited by Bess (1982), Dressel and Reichard (1970), Blau (1973), and Mintzberg (1979) about shared communication and cooperation may not be applicable in the research setting. Certainly, Hagstrom's (1965) observation is appropriate that researchers from different disciplines often combine to solve problems and after completing the task re-form their affiliations.

The study's result is instructive for higher education administration. The knowledge that regular interdepartmental communication can occur and form into a network is in itself an important dimension of the college setting. The administrator can play a significant role in encouraging this communication as well as utilizing the network for furthering academic pursuits. This study and the literature review indicated how the amount and type of communication flowing within and across departments can be assessed using communication network analysis. Depending on the topic or the need, the analysis can focus on identifying communication barriers, major communication linkers, or the general communication patterns of the system studied. The analysis can give insight to the administrator on how to introduce new ideas and how to improve communication within the academic setting. Such information would be particularly beneficial for a campus Research and Development Center.

A second conclusion is related to the methodology of the study. The divergent results found between Blau's postulation and this study and Friedkin's study may be explained by the differences in the methodologies of the studies. Blau's postulation was based on a general study of a sample of American colleges and universities. He did not focus on research institutions, nor did he stratify his data analysis to look at communication patterns by type of institution, academic discipline, or faculty member. Maybe most important of all, Blau did not use a communication network analysis methodology similar to Friedkin's study and this study. The two latter studies surveyed their population members about with whom they communicated on a given topic and, in the case of the present study, used a computer program to generate the patterns of communication behavior. Blau's methodology was not sophisticated and focused enough to identify actual communication patterns and properties.

The final conclusion concerns the content of the communication shared by the participants. The finding of networks, particularly a personal network, is not supported in the literature by Blau (1973), Dressel and Reichard (1970), and Mintzberg (1979). They describe the academic setting more as a series of isolated academic behaviors. Mintzberg noted that professionals in this setting are unwilling to extend themselves to interact with other non-disciplinary members. The members are described as staying within their primary work setting.

The finding of greatest integration within the production network and the all-function network is, however, supported by Hagstrom's (1965) comment on scientists' typically attacking a problem in an integrated way. The noteworthy finding, as well, is the existence of a personal or maintenance network. It is reasonable to conclude that the researchers in this study share a collegial atmosphere of friendship in addition to cooperation in their professional pursuits.

Recommended Research

The conclusions of this study have implications for future research in multidisciplinary integration for studies both at the present setting, as well as, at other campuses. Because the present study's conclusion supports Friedkin's suggestion that multidisciplinary integration may be found and encouraged at research settings, the same study should be replicated at other research settings in order to enhance the validity of these findings. Further research results are needed from other campuses in order to arrive at a generalization about multidisciplinary integration in research settings.

The appropriateness of the network analysis methodology as a dependable investigative strategy adds to the reliability of this study. The data measurement and analysis methodology used in this study was found in the literature review to be an effective means for identifying communication patterns. Of most importance, researcher error is reduced by the use of algorithms in a data analysis computer program such as NEGOPY.

In addition, the setting of the present study is comparable to other campus settings. The type of faculty person, the academic structure, and the involvement in a research problem, such as energy education, are very similar with many college campuses. As noted in the first chapter, the limitations of the study are not in the results or methodology.

Two ancillary studies are also suggested for future research. The first suggestion is to investigate why multidisciplinary integration can be found in research settings, particularly in the sciences, and have not been identified in other selected academic settings. The communication patterns of faculty in different settings could be surveyed, stratified, and analyzed as to how they compare with each other. The second suggestion is to do follow-up studies comparing personal-friendship networks with production networks. The personal-friendship networks may be more wide spread on college campuses than noted in the research. These networks may also play a significant role in maintaining existing multidisciplinary networks.

Concerning the research of multidisciplinary integration at the present setting, the suggestion is to assess the stability of the integration and the communication patterns over time. The study population could be investigated to determine if the same research content is being shared, if new research content is being communicated, or if any on-going interaction at all is occurring. Such an investigation could detect new, if any, networks, cliques, and communication roles.

The faculty who played communication bridging roles could also be studied for stability as well, to ascertain if they regularly play such roles in research communication on campus. These persons may be critical communicators who need to be considered in the dissemination of information. The type of persons in these roles could also be studied. Variables could be determined for them (i.e. status, length of tenure, type of research, type of research support, etc.) and analysis conducted on the relationship of the variables with the persons' communication roles.

One of the benefits in determining communication networks is the identification of member information needs and roles. Isolates and information flow blockages can be located and organizational intervention strategies developed to open up these communication passages. A practical reason for replicating this study could be to collect data for improving the research information flow in this setting. A secondary value of this study could be to stimulate and to enhance the collegial atmosphere in the present study's setting.

The enhancement of the research information flow is suggested as a function of the Research and Graduate Studies Office. This office has the primary responsibility for coordinating campus research and has records on current faculty involvement in this activity. The network analysis of research communication could be an ongoing process focusing on separate research topics and/or personnel. The analysis would produce the patterns of who is communicating with whom, as well as, who is doing what. In this way, the opportunity is available to identify the current campus research, provide better coordination of it, and enchance the personnel's flow of communication through intervention activities.

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY

Bridges -- Group members who have linkages to one or more groups (Albrecht, 1978).

Centrality -- A person is in a central position when that person is strategically located on the shortest communication path connecting pars of others (Bavelas, 1948). These positions can therefore facilitate, impede or bias the transmission of messages (Freeman, 1977).

Clique -- A subset of an organization consisting of three or more members each in a symmetric relation to each other member of the subset, and provided there is no element outside the subset that is in a symmetric relation to each of the elements of the subset (Luce and Perry, 1949).

Communication Network -- A series of linkages based on communication content (Farace, Monge, and Russell, 1977). The linkages comprise all possible communication pathways between members within a system's boundary (Richards, 1975).

Communication Roles -- Group members are differentiated according to their range of communication linkages (Albrecht, 1978). The roles exert influence over the content and flow of information in the system (Likert, 1961).

Density -- The degree to which sets of system members are interlinked or interconnected (Farace, Monge and Russell, 1977).

Dyad -- Two nodes who are linked to each other (Richards, 1975).

Energy Education Projects -- Those areas related to the discovery and dissemination of energy concepts and data. Energy Education is concerned with research, instruction, as well as the administration of energy projects. The energy education field does not include retrofitting of campus buildings for energy conservation, but it would include educational materials on energy awareness, research into alternative energy sources, and the development of energy management programs.

Invisible Colleges -- An elite network of mutually interacting and productive scientists within a research area (Price, 1963).

Isolates -- Individuals who have little if any contact with other members of the organization (France, 1978). Richards (1975) further defines a type one isolate as a person with no links and a isolate type two as a person connected to only one other person, who is not an isolate.

Liaisons -- Individuals who link groups but who are not themselves group members (Albrecht, 1978).

Links -- Measured relationships between individual nodes (Farace and Mabee, 1978).

Nodes -- The entities comprising the network. Usually nodes are people, but nodes my also represent other relationships such as among roles and among organizations (Farace and Mabee, 1978).

Reciprocal -- An agreement by the partner to the relationship indicated by the respondent (Rogers and Kincaid, 1981).

Reciprocity -- The percentage of links a person indicates which are also agreed upon by those who are mentioned (Farace, Monge, and Russell, 1977).

Rules -- Guide the structure of interaction and hence the type of messages communicated. Selection of topics, the length of discussion, and the number of disturbances are regulated by "rules" (Albrecht, 1978).

Social Network -- A social structure composed of members connected through communication of common topic, interest, or discipline (Granovetter, 1976).

Tree Node -- An individual who is not a member of a clique but who has a relationship with an isolate type two and with a clique member (Richards, 1975).

APPENDIX B

INSTRUCTIONS AND NETWORK ANALYSIS QUESTIONNAIRE

February 19, 1981

TO: Campus Energy Personnel

FROM: Ron Stump
108 Student Services Bldg.
3-3860

I would like your assistance with a study of the communication pattern between the faculty/staff involved with campus energy education, research, and extension.

The aim of the study is to identify and to improve the quality of information exchange. It is hoped that as a result of this study information about research results, available funding grants, services, and proposed studies will be more readily accessible to the campus energy faculty/staff. To accomplish this goal you and other faculty/staff in the energy field at Michigan State University are being asked to describe your campus communication contacts related to energy. With this information, the information flow related to energy can be characterized for Michigan State University.

The goals and the nature of this study are familiar to Jon Bartholic, Agricultural Experiment Station; Bill Cooper, Zoology; Herman Koenig, Center for Environmental Quality; Tom Edens, Agriculture Economics; and Adger Carroll, Cooperative Extension. You may wish to contact me at 3-3860, or one of them if you have any questions about the study.

The description of your communication will be obtained by the enclosed questionnaire. Based on pre-testing, it is estimated that it will take you roughly fifteen minutes to complete the questionnaire. Please be as thorough and honest as possible in your replies.

Please return the completed questionnaire in the enclosed envelope within a week to Ron Stump, 108 Student Services Bldg. A summary of the results of the study will be sent to you, if you indicate an interest in receiving a copy. Thank you for your assistance.

RS/ds

PERSONAL DATA SHEET

Name____
First   Middle Initial   Last

Department____

College____

Campus Address___________________________________Campus Phone_____________

Are you the Director ( ), Co-director ( ), or a staff member of an energy project?

Are your energy-related activities at the University primarily involved with:
(check all that apply)

______Teaching   ______Research   ______Public Service

Title of Project(s)
or Activity(s):

1.____

2.____

3.____

4.____

Products or major outcomes expected__________________________________

____

____

____

Primary audiences/users of project outcomes___________________________

____

____

Would an updated directory of MSU energy projects and personnel be of value to you?

____

____

Would you like a summary of the study's results?   Yes ( )   No ( )

Please complete the attached Energy Contact Questionnaire and <u>return it with this personal data sheet</u> in the enclosed envelope within a week.

ENERGY CONTACT QUESTIONNAIRE INSTRUCTIONS

On the attached questionnaire, you will be asked to describe your energy related communication with other energy personnel on-campus. You will be presented with a list of faculty/staff at Michigan State University and asked to report how much you communicate with them in energy matters, and generally what function such communication serves.

The list of names are presented with three columns next to them. These columns are headed by the description of three communication functions. The functions are Work-Related (getting the work done), New Ideas-Related (new ideas and ways to accomplish goals), and Personal-Related (social relations).

Please read through the list of names. When you come to a person with whom you communicate estimate roughly how many hours you communicate with this person in an average month about work, ideas, and personal topics. Consider the average month to be during a normal academic term.

Record your estimated number of hours per average month in each corresponding box. Round parts of hours up to the nearest hour. Remember that communicating with a person occurs whenever you contact someone or when someone makes contact with you through face-to-face conversation, meetings, written work, telephone conversations, etc.

If you have no contact with a particular person in an average month of a normal term, leave the box blank and go on. Likewise, if you have work-related contact with a person but no person-related contact, mark the work-related box with your estimate and leave the person-related box blank. When you come to your name, circle it and leave the boxes blank.

A sample of the questionnaire is presented on the next page.

ENERGY CONTACT QUESTIONNAIRE

SAMPLE

(Please circle your name)

	NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH		
	WORK RELATED	IDEAS RELATED	PERSONAL
01 John Daly	5		
02 Mary Cruso	2		15
03 Laura Uplet			
04 Marcy Sachs			

EXPLANATION OF SAMPLE:

In this example, Laura Uplet has estimated the number of hours she communicates with other energy personnel in an average month (during working and non-working hours). She first circled her name on the list. Next, she estimated that in an average month, she communicated with John Daly about five hours about work-related matters and not at all about ideas and personal matters. Next, she estimated that in an average month, she communicated with Mary Cruso for two hours concerning her work, not at all about new ideas, and 15 hours concerning personnal matters. She does not communicate with Marcy Sachs in an average month.

Remember that communication contacts occur when you contact someone else OR they contact you, by phone, memo, or in person.

ENERGY CONTACT QUESTIONNAIRE

DESCRIPTION OF COMMUNICATION FUNCTIONS

WORK RELATED: Writing reports and proposals, research, teaching, etc.

NEW IDEAS RELATED: New ways to do things, innovative things to do, etc.

PERSONAL RELATED: Interpersonal relationships, social interaction, counseling people.

	NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH		
(Please circle your name)	WORK RELATED	IDEAS RELATED	PERSONAL
001 Mike Abkin			
002 Edith Allen-Schult			
003 Robert Anderson			
004 Charles Arntzen			
005 Jes Asmussen			
006 Fred Bakker-Arkema			
007 Robert Bandurski			
008 Jon Bartholic			
009 George Bird			
010 Roy Black			
011 Robert Boger			
012 Georg Borgstrom			
013 Maureen Bowman			
014 Roger Brook			
015 Galen Brown			
016 John Cantlon			

(Please circle your name)	NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH		
	WORK RELATED	IDEAS RELATED	PERSONAL
017 Adger Carrol			
018 Duncan Case			
019 Daniel Chappelle			
020 Larry Connor			
021 Bill Cooper			
022 Eric Crawford			
023 Gerald Crawley			
024 Doug Cron			
025 Carol Dahl			
026 Don Dickerson			
027 Don Dickman			
028 David Dwyer			
029 John Eastman			
030 Tom Edens			
031 Don Edwards			
032 Earl Erickson			
033 Merle Esmay			
034 Vince Farace			
035 Anne Field			
036 Philip Filner			
037 Fred Fink			
038 Cynthia Fridgen			
039 Joe Fridgen			
040 Stuart Gage			
041 Mitchell Geasler			

(Please circle your name)	NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH WORK RELATED	IDEAS RELATED	PERSONAL
042 John Gerrish			
043 Norman Good			
044 Eric Grulke			
045 Gerald Haarer			
046 Fred Hall			
047 Roger Hamlin			
048 James Hanover			
049 Craig Harris			
050 Bud Hart			
051 Irene Hathaway			
052 Martin Hawley			
053 Dean Haynes			
054 Sherwood Haynes			
055 Denny Heldman			
056 Zane Helsel			
057 Martin Hetherington			
058 Donald Holecek			
059 Allan Hollingsworth			
060 Hank Huber			
061 John Huber			
062 Dennis Hudson			
063 Peter Kakela			
064 Dennis Keefe			
065 Joanne Keith			
066 Ron Kerber			

(Please circle your name)	NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH		
	WORK RELATED	IDEAS RELATED	PERSONAL
067 Kyle Kittleson			
068 Herman Koenig			
069 Kathryn Kolasa			
070 Otto Krauss			
071 Rex Lamore			
072 Nancy Landes			
073 Larry Libby			
074 Theodore Loudon			
075 Les Mack			
076 Dick McLeod			
077 Tom McPeak			
078 Martha Molder			
079 Lewis Moncrief			
080 Don Montgomery			
081 William Mooney			
082 Bonnie Morrison			
083 Denton Morrison			
084 Robert Muth			
085 Bob Neumann			
086 Dick Niehoff			
087 Steve Orlick			
088 Gerald Park			
089 Lucas Parsch			
090 Wally Piper			
091 Carl Ramm			

NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH

	(Please circle your name)	WORK RELATED	IDEAS RELATED	PERSONAL
092	C. A. Reddy			
093	Bill Reusch			
094	Alvin Rippen			
095	Michael Rogers			
096	Ron Rosenberg			
097	Lowell Rothert			
098	Alan Rotz			
099	Lester Schick			
100	Ger Schultink			
101	Gerald Schwab			
102	James Shaffer			
103	Robert Snow			
104	Larry Sommers			
105	Ajit Srivastava			
106	Jim Steffe			
107	Milton Steinmueller			
108	Bill Stout			
109	Barbara Stowe			
110	Otto Suchsland			
111	William Thomas			
112	Ed Tolbert			
113	Larry Tombaugh			
114	R. L. Tummala			
115	Gary VanEe			
116	Eileen VanRavenswaay			

(Please circle your name)	NUMBER OF HOURS COMMUNICATING IN AN AVERAGE MONTH WORK RELATED	IDEAS RELATED	PERSONAL
117 Nancy Veenstra			
118 Maurice Vitosh			
119 John Waller			
120 Bruce Wilkinson			
121 Sylvan Wittwer			
122 Truman Woodruff			
123 David Wright			
124 Melvin Yokoyama			
125 Roland Zapp			
126 James Zuiches			

List additional names below if not all of your campus energy contacts are provided. Energy personnel are those campus full-time faculty/staff directly involved in energy education, research, and extension. Do NOT include personnel doing energy conservation projects for University facilities or those administrative officers involved with payroll, personnel, purchasing, etc.

REFERENCES

REFERENCES

Aiken, M. and Hage, J., "Organizational Interdependence and Intra-Organizational Structure." American Sociological Review, 33, #6: 912-928, December, 1968.

Alba, R.D. and C. Kadushin, "The Introduction of Social Circles: A New Measure of Social Proximity in Networks." Sociological Methods and Research, 5: 77-102, 1976.

Albrecht, T.L., Communication and Perceptions of Organizational Climate: An Empirical Analysis. Unpublished doctoral dissertation, Department of Communication, Michigan State University, 1978.

Barnes, J.A., Social Networks. Reading, Massachusetts, Addison-Wesley, Modular Publications in Anthropology, 26: 1-29, 1972.

Barnes, J.A., "Network Analysis: Orienting Notion Rigorous Technique, or Substantive Field of Study." in P.W. Holland and S. Leinhardt (Eds.), Perspectives on Social Network Research. New York, New York: Academic Press, 1979.

Bavelas, A., "A Mathematical Model for Group Structure." Applied Anthropology 7: 16-30, 1948.

Berlo, D.K. "Human Communication: The Basic Proposition." Unpublished manuscript, Department of Communication, Michigan State University, East Lansing, 1970.

Bernard, H.R. and Killworth P.D., "On the Social Structure of an Ocean-Going Research Vessel and Other Important Things." Social Science Research, 2: 145-184, 1973.

Bernard, H.R. and Killworth P.D., "On the Structure and Effective Sociometric Relations in a Closed Group Over Time." Connections, 1: 44, 1978.

Bernard, H.R., Killworth, P.D., and Sailer, L., "Summary of Research on Informant Accuracy in Network Data, and on The Reverse Small World Problem." Connections, 4, #2: 11-25, 1981.

Bernstein, P., "Oil a-plenty but OPEC calls shots." The Detroit Free Press. 8B, September 1, 1980.

Bess, J.L., University Organization. New York, New York: Human Sciences Press, Inc. 1982.

Beyer, J.M. and Lodahl, T.M., "A Comparitive Study of Patterns of Influence in United States and English Universities." Administrative Science Quarterly, 21: 104-129, 1976.

Blau, P.M., The Organization of Academic Work. New York: John Wiley and Sons, Inc., 1973.

Blau, P.M., "Parameters of Social Structure." American Sociological Review, 39, #5: 615-635, October, 1974.

Boissevain, J., Friends of Friends; Networks, Manipulators and Coalitions. Oxford: Basil Blackwell, 1974.

Bolman, F.deW., "Needed Research in Administration of Higher Education." Educational Record. XLVI: 166-176, Spring, 1965.

Bott, E., "Urban Families: Conjugal Roles and Social Networks." Human Relations. 8: 345-384, 1955.

Breiger, R.L. "Career Attributes and Network Structure: A Block Model Study of a Biomedical Research Specialty." American Sociological Review, 41: 117-135, 1976.

Burgess, R.L., "Communication Networks and Behavioral Consequences." Human Relations. 22: 137-159, 1968.

Burt, R.S., "Models of Network Structure." Annual Review of Sociology, 6: 79-141, 1980.

Burt, R.S. and Bittner, W.M., "A Note on Inferences Regarding Network Subgroups." Social Networks, 3, #1: 71-88, 1981.

Bushnell, D. and Rappaport, D. (Eds.), Planned Change in Education. New York: Harcourt Brace Jovanovitch, Inc., 1971.

Champagne, A. and Klopfer, L., Criteria for Effective Energy Education. Pittsburg, Pennsylvania: University of Pittsburgh, Learning Research and Development Center, 1978.

Chapin, F.S., "Trends in Sociometrics and Critique." Sociometry, 3: 245-262, 1940.

Crane, D., "Social Structure in a Group of Scientists: A Test of the 'Invisible College' Hypothesis." American Sociological Review. 34: 335-352, 1969.

Crane, D., Invisible Colleges: Diffusion of Knowledge in Scientific Communities. Chicago: University of Chicago Press, 1972.

Crawford, Susan, "Informal Communication among Scientists in Sleep and Dream Research." An unpublished doctoral dissertation, University of Chicago, 1970. Cited by N.E. Friedkin, "University Social Structure and Social Networks among Scientists." American Journal of Sociology, 83: 1444-65, 1978.

Dressel, P. and Reichard, D.J., "The University Department Retrospect and Prospect." The Journal of Higher Education, XLI, #5: 387-402, 1970.

Erickson, B.H., Nosanchuk, T.A., and Lee, E., "Network Sampling in Practice: Some Second Steps." Social Networks, 3, #2: 127-136, 1981.

Farace, R.V. "Organizational Communication". in C. Book (Ed.), Human Communication: Principles, Contexts, and Skills. New York: St. Martin Press, Inc., 1978.

Farace, R.V. and Connelly, R.A., "Organizational Communication Correlates of Herzberg's Theory of Work Satisfaction." Readings in Organizational Communication. Unpublished manuscript, Michigan State University, 1970.

Farace, R.V. and Johnson, J.D., "Comparative Analysis of Human Communication Networks in Selected Formal Organizations." Paper presented at the International Communication Association, New Orleans, 1974.

Farace, R.V. and Mabee, T., "Communication Network Analysis Methods." Draft of chapter in P. Monge and J. Cappella (Eds.), Multivariate Analysis Techniques in Communication Research. New York: Academic Press, 1978

Farace, R.V., Monge, P.R., and Russell, H.M., Communicating and Organizing. Reading, Mass.: Addison-Wesley, 1977.

Fenemma, M. and Schift, H., "Analyzing Interlocking Directorates: Theory and Methods." Social Networks, 1: 297-332, 1978/79.

Freeman, L.C., "A Bibliography of Social Networks." Monticello, Illinois, Council of Planning Librarians Exchange Bibliography, 1170-1171, 1976.

Freeman, L.C., "Centrality in Social Networks Conceptual Clarification." Social Networks, 1: 215-239, 1978/79.

Freeman, L.C. "A Set of Measures of Centrality Based on Betweenness." Sociometry, 40, #1: 1977.

Friedkin, N.E. "University Social Structure and Social Networks Among Scientists." American Journal of Sociology, 83: 1444-65, 1978.

Friedkin, N.E. "The Development of Structure in Random Networks: An Analysis of the Effects of Increasing Network Density on Five Measures of Structure." Social Networks, 3, #1: 41-52, 1981.

Granovetter, M.S. "The Strength of Weak Ties." American Journal of Sociology, 78: 1360-1380, 1973.

Granovetter, M.S., "Network Sampling: Some First Steps." American

Journal of Sociology, 81: 1287-1303, 1976.

Guetzhow, H., "Communication in Organizations." in March, J.G. (Ed.), Handbook of Organizations. Chicago: Rand-McNally, 1965.

Hagstrom, W. O., The Scientific Community. New York: Basic Books, 1965.

Hammer, M., "Predictability of Social Connections Over Time." Social Networks, 2:165-180, 1979/1980.

Hicks, H. The Management of Organizations. New York: McGraw-Hill, 1967.

Huse, E. and Bowditch, J., Behavior in Organizations: A Systems Approach to Management. Reading, Mass.: Addison-Wesley, 1973.

Jacobson, E. and Seashore, S., "Communication Patterns in Complex Organizations." Journal of Social Issues, 7: 28-40, 1951.

Killworth, P.D. and Bernard H.R., "Informant Accuracy in Social Network Data." Human Organization, 35, #3: 269-296, 1976.

Knoke, D. and Kuklinski, J.H., "Network Analysis." in J.L. Sullivain and R.G. Niemi (Eds.) Quantitive Applications in the Social Sciences. Beverly Hills: Sage Publications, 1982.

Larkin, T.J., "Network Analysis As An Investigative Tool For Organizational Communication." Unpublished masters thesis, Department of Communication, Michigan State University, 1978.

Leavitt, H.J., "Some Effects of Certain Communication Patterns on Group Performance." Journal of Abnormal and Social Psychology, 46: 38-50, 1951.

Likert, R., New Patterns of Management. New York: McGraw-Hill, 1961.

Lin, N., The Study of Human Communication. Indianopolis: Bobbs-Merrill, 1973.

Luce, D. and Perry, A., "A Method of Matrix Analysis of Group Structure." Psychometrika, 14: 1949.

MacDonald, D., "Communication Roles and Communication Content In A Bureaucratic Setting." Unpublished doctoral dissertation, Department of Communication, Michigan State University, 1970.

McConnell, T.R., "Needed Research in College and University Organization and Administration." in T. Lunsford (Ed.), The Study of Academic Administration. Boulder, Colorado, Western Interstate Commission for Higher Education, 1963.

Millett, J.D., The Academic Community. New York: McGraw-Hill, 1962.

Mintzberg, H., The Structuring of Organizations. Englewood Cliffs, N. J.: Prentice-Hall, 1979.

Mitchell, J.C., "The Concept and Use of Social Networks." in J.C. Mitchell (Ed.), Social Networks in Urban Situations. Manchester, England, Manchester University Press, 1969.

Mitchell, J.C., "Social Networks." Annual Review of Anthropology, 3: 279-299, 1974.

Monge, P.R., Edwards, J.A., and Kirste, K.K., "The Determinents of Communication and Communication Structure in Large Organizations. A Review of Research." A paper presented at the annual meeting of the International Communication Association, Chicago, 1978.

Moran, W.F., "The Study of University Organizations." Journal of Higher Education, XXXIX: 144-155, 1968.

Moreno, J.L., Who Shall Survive? Beacon, New York: Beacon House, Inc, 1953.

Mouton, J.S., Blake, R.R., and Fruchter, B., "The Reliability of Sociometric Measures." Sociometry, 18, 1: 7-48, 1955.

Mulkay, M.J., Gilbert, G.N. and Woolgar, S., "Problem Areas and Research Networks in Science." Sociology, 9: 187-203 1975.

Mullins, N.C., "The Distribution of Social and Cultural Properties in Informal Communication Networks Among Social Scientists." American Sociological Review, 33, #1: 786-797, 1968.

Mullins, N.C., "The Development of a Scientific Specialty: The Phage Group and the Origins of Molecular Biology." Minerva, 10: 51-82, 1972.

Nehnevajsa, J., "Sociometry: Decades of Growth." Sociometry, 18, 2: 304-351, 1955.

Perkins, J.A., The University As An Organization. McGraw-Hill, New York, 1973.

Porter, L.W., Lawler, E.E., and Hackman, J.R., Behavior in Organizations. McGraw-Hill, New York, 1975.

Price, D.J.deS., "Networks of Scientific Papers." Science, 149: 510-515, 1965.

Richards, W. A Manual for Network analysis: Using the NEGOPY Network Analysis Program. Institute for Communication Research, Stanford University, 1975.

Rogers, E.M., Diffusion of Innovations. 3rd Edition, New York: The Free Press, 1983.

Rogers, E.M. and Agarwala-Rogers, R., Communication in Organizations. New York: The Free Press, 1976.

Rogers, E.M. and Bhowmik, D.K., "Homophily and Heterophily: Relational Concepts for Communication Research." The Public Opinion Quarterly, 34: 523-538, 1971.

Rogers, E. and Kincaid, D.L., Communication Networks. New York: The Free Press, 1981.

Schriver, J., (Ed.), "Energy and The University: A Guide to Energy Programs and Resources at Michigan State University." Lifelong Energy Education Project, East Lansing, Michigan: College of Education, Michigan State University, 1979.

Schwartz, D. and Jacobson, E., "Organizational Communication Network Analysis: The Liaison Communication Role." Organizational Behavior and Human Performance, 18: 158-174, 1977.

Shaw, M.E., "Communication Networks." in L. Berkowitz (Ed.), Advances in Experimental Social Psychology, 1: 111-147, 1964.

Stern, R.N., "The Development of an Interorganizational Control Network: The Case of Intercollegiate Athletics." Administrative Science Quarterly, 24: 242-266, 1979.

Stokman, F.N., Third World Group Formation in the United Nations: A Methodological Analysis, Amsterdam, University of Amsterdam Press, 1977.

Taylor, J., "An Empirical Examination of the Referential Function of Informal Communication Groups." Unpublished masters thesis, Department of Communication, Michigan State University, 1976.

Thayer, L., Communication and Communication Systems. Homewood, IL: Richard Irwin, 1968.

Tucker, A. Chairing the Academic Department. American Council on Education, Washington D.C., 1981.

Veysey, L.R., The Emergence of the American University. Chicago: University of Chicago Press, 1965.

Weiss, R.S., and Jacobson, E., "A Method for the Analysing of the Structure of Complex Organizations." American Sociological Review, 20: 661-668, 1955.

White, H.C., Boorman, S.A., and Breiger, R.L., "Social Structure from Multiple Networks. I Blockmodels of Roles and Positions." American Journal of Sociology, 81: 4, 730-780, 1976.

Whitten, N.E. and Wolfe, A.W., "Network Analysis." in J.J. Hongimann (Ed.), Handbook of Social and Cultural Anthropology, Chicago: Rand McNally, 1973.

Wolfe, A.W., "The Rise of Network Thinking in Anthropology." Social Networks, 1, #1: August, 1978.

Woodburne, L.S., Principles of College and University Administration.
Stanford: Standford University Press, 1958.