THE ROLE OF PERSON TO PERSON COMMUNICATION NETWORKS IN THE DISSEMINATION OF INDUSTRIAL TECHNOLOGY*

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The development of networks for the dissemination of educational innovation might potentially benefit from the study of naturally occurring and stimulated networks in other areas. For the past several years, a small group at MIT's Sloan School of Management has been studying the operation of person to person communication networks in the transfer of industrial technology. This paper will review some of the results of these studies with a special view toward their applicability in the educational sector.

The MIT studies have had two specific, not entirely independent, foci. First, they looked outward from the individual organization and asked the question, how best to import new relevant technology. Then taking a slightly broader perspective they asked the question, given a number of institutions, some presumably working in concert, others not, how best to insure the desired dissemination of technology among them. A similar approach will be taken here. First we will examine the process of importing technology into a social system, then we will turn out attention to inter-organizational relations at two levels.

The Organization as an Importer of Technology

There are at least three general techniques which an organization can employ to keep abreast of relevant technological developments. First, to the extent that it is growing or enjoys a regular turnover of personnel, it can attempt to hire new employees who are acquainted with recent developments in the relevant technologies. In other words, it imports new technological know-how by hiring those who possess it. Second, since some technological developments are well documented, it can invest in the means to provide its members with access to this documentation. Finally it can encourage or arrange for direct formal or informal personal contact between its members and those outsiders possessing the desired technological information.

Direct Personal Contact Outside of the Organization

Turnover and inter-organizational movement of personnel is a topic to which we shall return later in the present paper. It is certainly an extremely important channel for technology transfer, but is best treated under inter-organizational relations. The documentation channel is also one which we shall defer. This is partly because it has been treated so extensively elsewhere, but more specifically because it falls generally outside of the topic of networking.

The last of the three general techniques is the one to which we shall direct our attention, at this point. In our earliest research (Allen, 1964; 1966) it was shown that a consistent inverse relation existed between direct personal contact outside of one's organization and technical problem solving performance. Similar results have been reported by a number of other investigators concerned with communication in research and development. A very consistent inverse relation has been found between external communication and performance of engineers and scientists in industrial organizations. Basic research scientists in universities, on the other hand, have demonstrated a very strong direct relation between performance and communication with colleagues in their specialty outside of their university. An explanation for this difference lies in a subtle but major distinction between science and technology. Science may be universal, and a scientist may be fully capable of understanding the nature of the problems and approaches employed by other scientists in his specialty anywhere in the world. They are all working toward the same goals and operating within a common social system. Technology, on the other hand, is not universal. It is highly localized. Technological problems are generally not defined in universal terms. They are defined in terms of the interests, goals and local culture of the organization, in which they

are being attacked. Similar technological problems become defined in very dissimilar ways by the organizations working on them. Organizations differ in their definition of goals and in their value systems. They tend to develop sub-cultures of their own. Technological problems are then defined within the value structure of this sub-culture. Certain types of solution, which may be perfectly acceptable in one organization, will simply not work when applied to the same problem in another organization. This is not usually apparent to an outsider. Consequently, it is very difficult to fully communicate the nature of a technological problem to a person outside of the organization. Both parties may think that the outsider understands the problem, but his understanding is usually incomplete and his proposed solutions are not likely to fully match the locally-defined solution space. As a result, the externally defined solutions perform less well, and we have the resulting inverse relation between external consultation and technical performance.

The Technological Gatekeeper and Communication Outside of the Organization

The apparent difficulty in communicating effectively across organizational boundaries, coupled with results that showed intra-organizational communication to be very strongly related to R&D performance (Allen, 1964; 1966; 1970; Baker, et.al., 1967) left the problem of transferring technology between organizations largely unresolved. Of course, there is always the contribution from turnover of technical staff. And this is an extremely important vehicle for technology transfer. Still it did not seem a sufficient explanation. There must be other channels as well. If the internal consultant is, as all the evidence would indicate, such an excellent source of technical information, where does he acquire his information?

The second phase of the research was directed to answering this question. What we wanted to do was to move one node back in the internal communication network and determine where the inputs to that point originated.

To accomplish this goal, a number of R&D laboratories were surveyed to determine the communication patterns of their technical staffs. Two methods were used. In some laboratories, individuals were asked to name those other individuals with whom they communicated regularly about technical or scientific topics. A minimum frequency of once a week or once a month was specified in the question. In other laboratories, communications were sampled over periods varying from three months to a year. Once a week, on randomly chosen days, questionnaires were distributed. Each questionnaire listed the names of all members of the organization's technical staff. Respondents were asked to look down the list and check off the names of those with whom they had discussed a technical or scientific topic, on that day. After these had been collected for several months, the average frequency of communication between pairs of individuals could be computed. Networks could then be created for any frequency of communication, showing for example which pairs communicated at an average of at least once a month (Figure 1).

The two approaches produce reasonably comparable results, with some slight increase in the correctedness of networks based on the second of the two approaches.

In the tradition of such analyses (Lazarfeld, et.al., 1944; Katz & Lazarfeld, 1955; Katz, 1957; Coleman, et.al. 1966) high communicators, or stars, were first identified and then compared with their less communicative colleagues. The key dimension on which comparison was made was the degree of technical communication outside of the organization. The stars of the internal network were found to have a significantly higher degree of long term informal contact

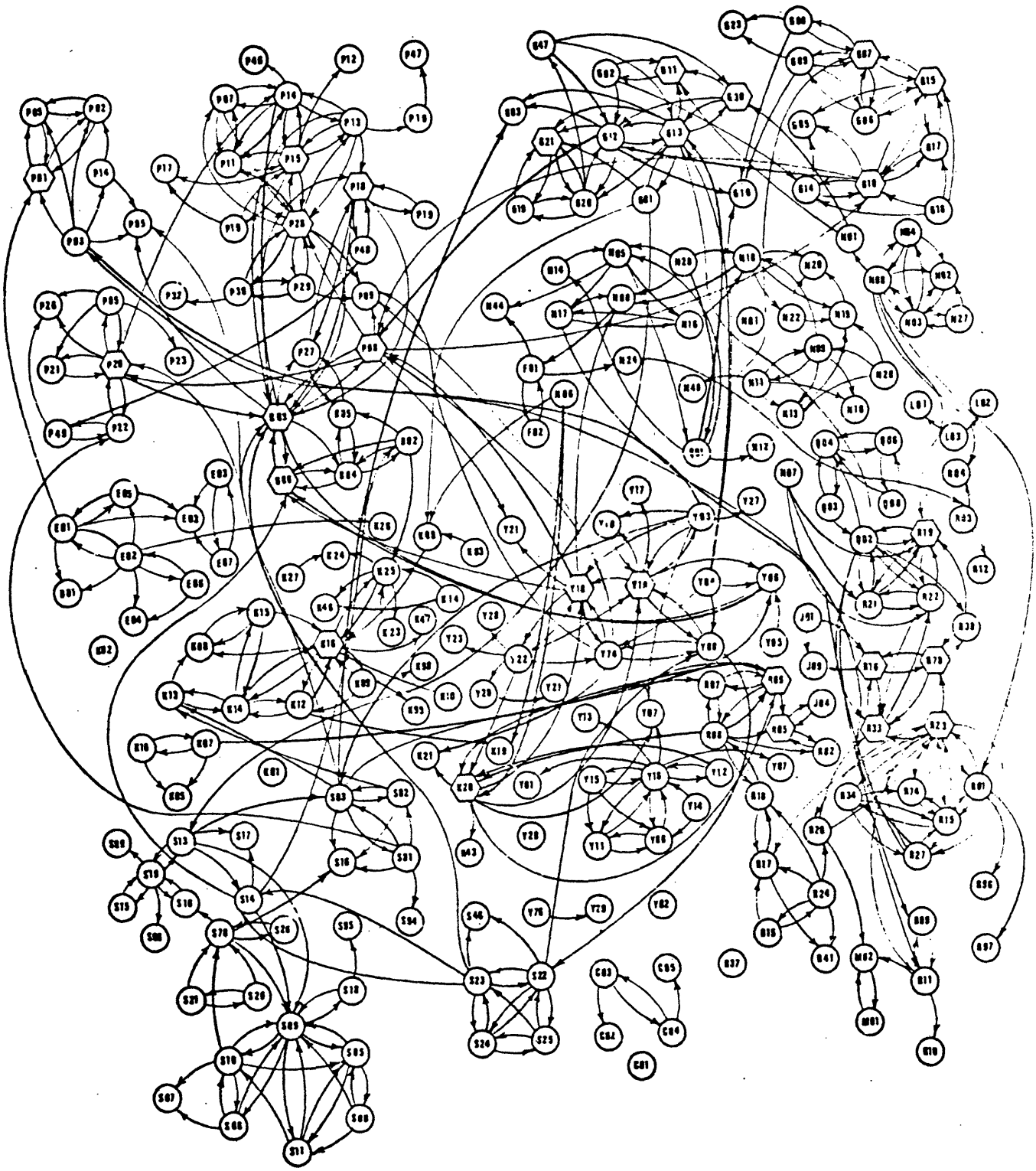

Figure 1. Communication Network of an R&D Laboratory. (Based on an Average Frequency of Communication of at Least Once Per Week.)

Note: Gatekeepers are represented as hexagons

(From Allen, 1977a)

with colleagues outside of their organization and to have a significantly higher readership of the professional scientific and engineering literature (Allen, 1977a; Allen & Cohen, 1969; Frost & Whitley, 1971; Taylor & Utterback, 1975).

Those internal stars who also maintained a very high degree of external communication were labelled "technological gatekeepers" (Allen & Cohen, 1969). They were found to have a number of interesting characteristics. For example, they were not merely high communicators. They were high technical performers as well. They were over-represented at the lower levels of the organizational hierarchy, and seldom found near the top. Finally, they were not formally recognized by the organization but once the concept was described could usually be named quite accurately by the organization's members.

Some Limits to the Gatekeeper Concept

The results summarized above once again can be seen very clearly in a study of communication in a large research and development organization (Allen, et.al., in preparation). The organization supported work ranging from fairly fundamental scientific investigations through product and process development to what is called technical service, or very applied technical problem-solving adapted to the needs of specific customers. Relating project performance to extra-organizational communication, we find a fairly strong positive relation for research projects, but a negative or inverse relation for development projects (Figure 2). The relation for technical service projects was positive, but much weaker than that for research. In contrast, the variation in external communication across individual project members showed very different relations with performance (Figure 3). The degree to which members of research or technical service projects varied in their degree of external contact, bore very little relation to the performance of the

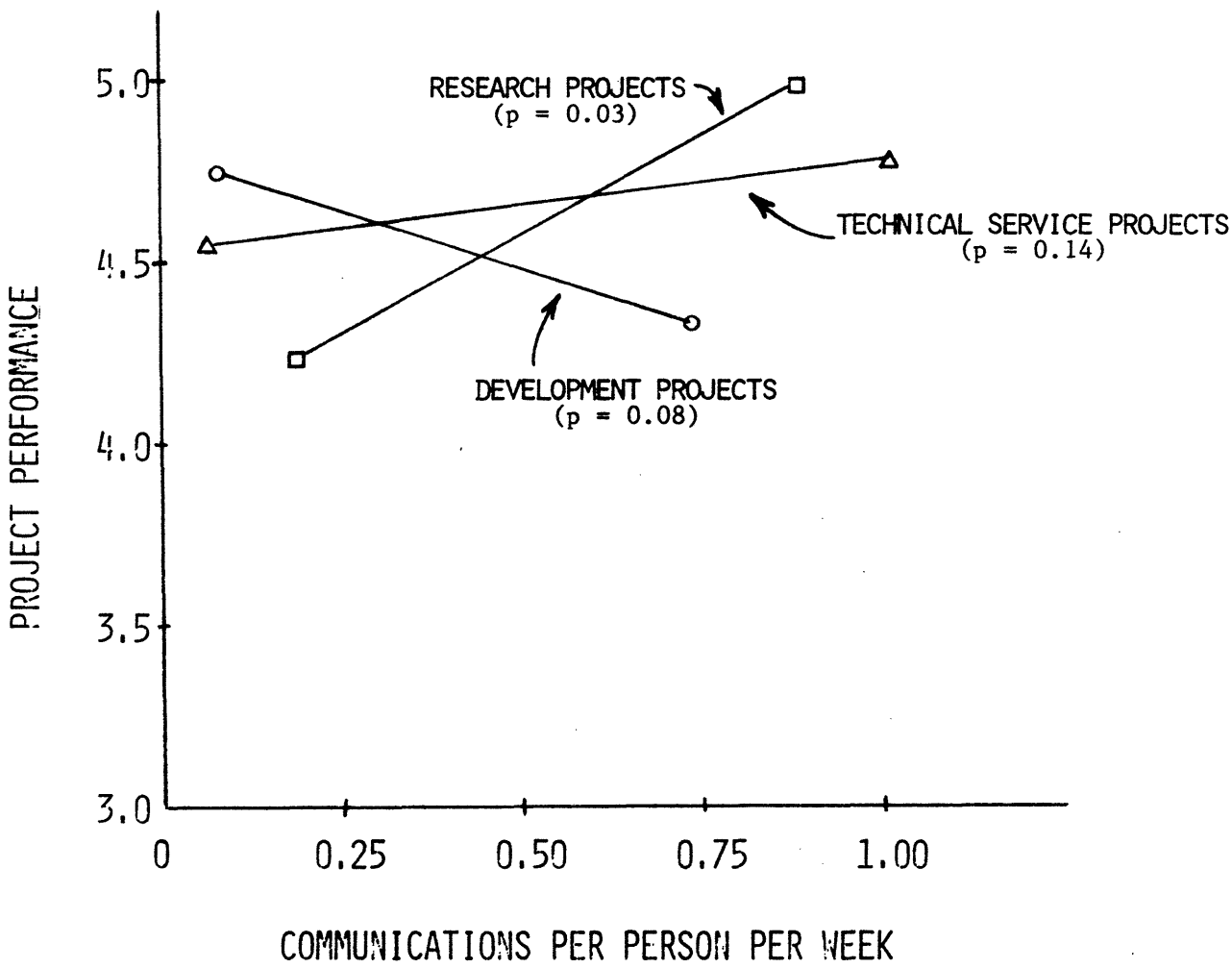

FIGURE 2. RELATIONSHIP BETWEEN PROJECT PERFORMANCE AND THE MEAN LEVEL OF PROFESSIONAL COMMUNICATION OUTSIDE THE ORGANIZATION.

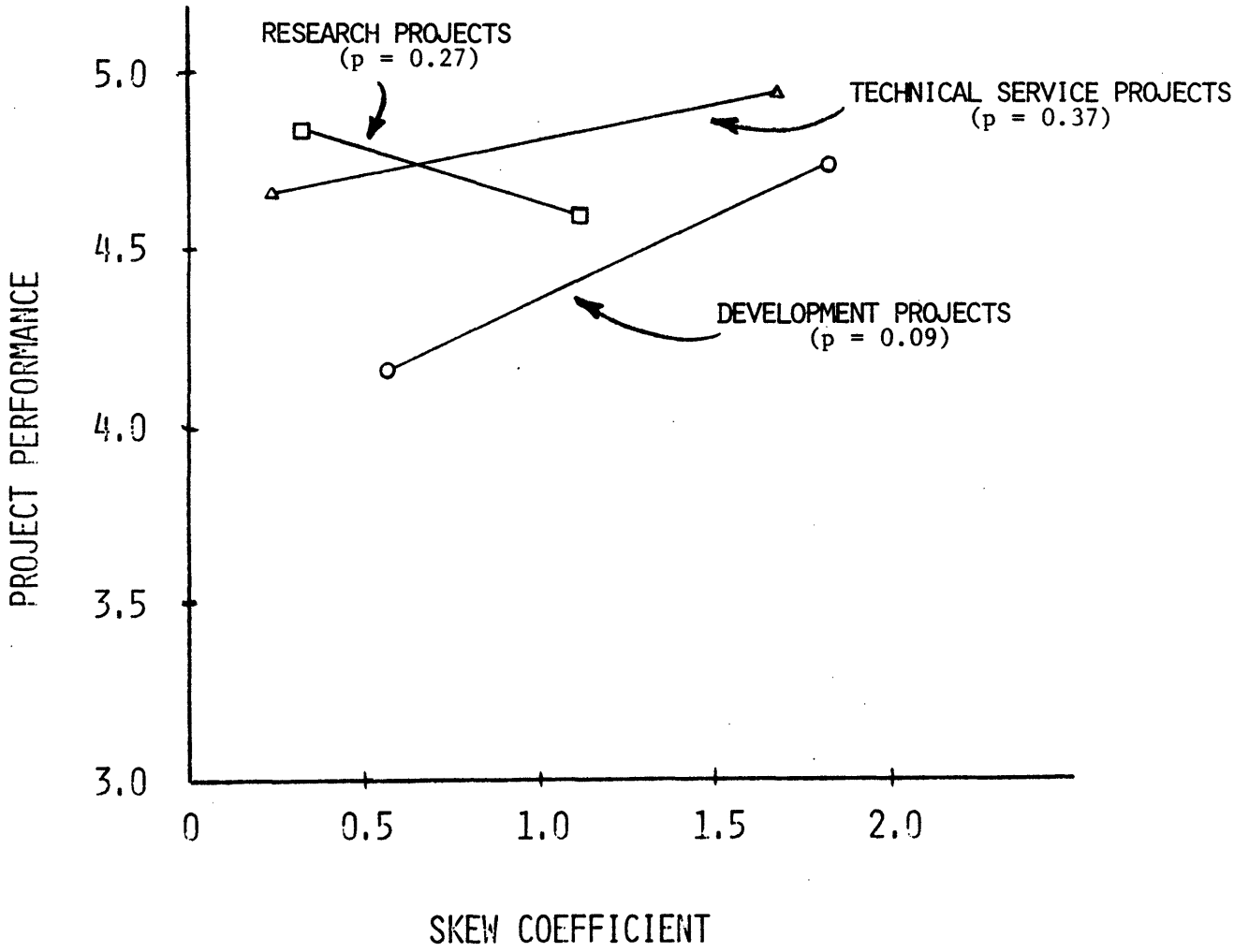

FIGURE 3. RELATIONSHIP BETWEEN PROJECT PERFORMANCE AND THE DEGREE TO WHICH THE DISTRIBUTION OF EXTERNAL PROFESSIONAL COMMUNICATION IS SKEWED ACROSS PROJECT MEMBERS.

project. On the other hand, the more those working on development projects varied in their external communication, the better the performance of the project. In other words, when research scientists uniformly increase their communication with the world outside of their organization, they improve their chances of producing a higher quality solution. In contrast, when development technologists decrease their average level of external communication but at the same time allow a few of their number to maintain or increase their communication, their probability of better quality solutions is enhanced. The technologists are better off facing up to the parochial nature of technology and allowing only those individuals who are capable of functioning in and understanding both their own and other social systems to assume responsibility for external communication. This is the logic behind the gatekeeper concept first proposed by Allen and Cohen (1969). Because technological problems are defined in local terms, most technologists have difficulty in communicating effectively with outsiders about their problems. Fortunately, however, there often appear a few individuals who maintain consistent ongoing contact outside of their organizations, who understand the way in which outsiders differ in perspective from their organizational colleagues, and who are able to translate between the two systems. The gatekeeper is able to understand external technological developments and to translate these into terms that can be understood by and are relevant to his organizational colleagues. The gatekeeper performs an extremely important role in many organizations. He is the principal channel for effectively transferring technology into the organization.

Limitations on the Applicability of the Gatekeeper Concept

The preceding presentation, in addition to showing the importance of

the gatekeeper role in organizations, also shows one area in which it is not important. These data and Hagstrom's (1965) earlier work indicate that basic research scientists have little need for the specialized role of the gatekeeper. In science, individuals are less constrained by local circumstances and are able to communicate effectively with colleagues, who share their research interests, regardless of where those colleagues might be. So the gatekeeper is really the offspring of technology. The parochial nature of technology created the need for gatekeepers, and it is only organizations pursuing technology, that will benefit from this role. This is also some indication that the gatekeeper is of great importance only when the technology is somewhat sophisticated. The results here are not as yet completely clear, but among the technical service projects, in the organization discussed earlier, there was little relation between project performance and either the mean level of external communication or the variation among individuals in external communication. There is some indication that in technical service projects, the administrative hierarchy assumed more of the responsibility for external communication. This is similar to the situation reported by Frost and Whitley (1971) where, in a laboratory providing consulting services in metallurgy, they found that first level supervisors provided the laboratory's principal connection to the world. The informal gatekeeper role, independent of the organizational hierarchy was somewhat less important in that laboratory.

These results probably stem from the fact that the technologies employed by technical service projects are more established, less dynamic and even more closely coupled to organizational goals than are the technologies used in product or process development. The formal organization, through its hierarchy, provides the vast majority of information required by technolo-

gists performing this service function. The need for creativity, while not absent, is certainly less in technical service. The technologies, being less complex, are more easily dealt with and understood by the management of the organization. It is only when the technologies become more complex, in the development projects, that the need arises for a specialized role, in which the individual is in close touch with the details of the work and conversant with developments in the specific technologies required.

What all of this leads to is a situation in which the concept of gatekeeper is important to organizations only within certain limited circumstances. When the organization is a basic research laboratory, gatekeepers are unnecessary, because the organization itself does not impede communication with the outside world. At the other end of the R&D spectrum, when the organization is concerned chiefly with the application of well-established technologies to well-specified situations, there is little need for gatekeepers since the organization is capable of structuring itself to provide the technical information needed by its members. It is only in the middle range of the science to technology or research to development spectrum that gatekeepers assume their full importance. When the organization is concerned with innovation and is itself contributing to technological advance the gatekeeper provides the most effective link between the organization's efforts and those being pursued elsewhere.

The Gatekeeper and Educational Technology

The gatekeeper concept seems to have wide appeal to those concerned with innovation in the educational sector. Everyone seems to be able to think of some individuals, who apparently fit the prescription. Some caution should be exercised, however, in formulating policy that would rely on the gatekeeper as the principal channel for transferring technology. There are certainly

areas where the concept will not apply. First there are the basic research institutions, universities primarily, where gatekeepers are less important. But this is not the area in which those concerned with education generally think of applying the gatekeeper idea. It is among educational practitioners that the idea has greatest appeal. This is where one has to be most cautious. If our most recent analyses are correct, the role assumes real importance only when the organization is both drawing on and contributing to a dynamic set of technologies. Practitioners, who are not themselves innovators or at least making some research contribution, would be excluded. This means that for the vast majority of those involved in education the gatekeeper cannot be assumed to provide access to current technology.

Gatekeepers and Opinion Leaders

An important distinction should be made at this point between the gatekeeper concept and the concept of opinion leader which Katz (1957), Rogers (Rogers and Shoemaker, 1971) and others have discussed. Gatekeepers and opinion leaders are similar in many ways, but differ along a number of critical dimensions. Perhaps the most important of these differences involves the type of social system in which they operate. Most studies of opinion leadership have been done inside of bureaucratic structures. They have dealt with farmers, physicians, consumers and others, who are generally not members of a common hierarchical organization. It is bureaucracy, with its control of reward systems and careers, and its emphasis on system boundaries that creates the barriers to communication described in the initial paragraphs of this paper. The gatekeeper arose to fulfill a need with which bureaucracy was incapable of dealing. When bureaucratic organization is weak or absent, as in the case of research scientists, farmers, physicians,

etc., there is little need for such a boundary-spanning role, as the gatekeeper. The boundary is not so well-defined and communication is not seriously impeded. When technology is stable, formal mechanisms can be employed by the organization to bring technology to its users. Perhaps some form of opinion leadership may exist in this situation, with contact occurrring among those at high levels in several organizations (Cf. Carlson, 1964). Internal diffusion is accomplished through the formal hierarchy of the organization. Bureaucracy is able to handle situations in which technologies are well-defined and stable, or when an innovation is already well-defined and packaged by the innovator or innovating organization.

It is when there exists a well-defined bureaucratic boundary and a dynamic technology, that the gatekeeper is important. The well-defined boundary, with its impedance to communication requires some boundary-spanning mechanism. The dynamic technology implies a need for someone, who is intimately conversant with it to play the role of introducing it to the organization. Of course, to be intimately conversant with a dynamic technology one must almost necessarily be contributing to it in a direct way, himself. Such direct technological contributors are seldom found in the higher levels of organizations. Therefore, it must be someone who is at or near the bottom of the organization, who accomplishes this feat. In other words, the organizational hierarchy is by-passed by informal relations developed by the gatekeeper with his colleagues outside of the organization. Information is then diffused within the organization, through informal contact, which is also independent of the hierarchy. This is the only way in which a dynamic technology can be continuously drawn into the organization. But it is an avenue that is only necessary when the conditions of bureaucratic organization and dynamic technology co-exist simultaneously.

An important corollary, that can be derived from the above is that only organizations which are themselves supporting work in more dynamic technologies can hope to keep abreast of these technologies.

Gatekeepers, in the strictest sense of the term will be useful only in organizations, which are themselves contributing to the development of educational technology. In other organizations, opinion leaders at higher levels of the bureaucratic hierarchy must be relied on to provide access to information about innovations, and this information can be disseminated formally within the organization. The distinction is one of organizational level and degree of formality in the internal dissemination process. The gatekeeper functions at the lowest levels in an organization and relies entirely on informal processes for dissemination. The opinion leader operates at much higher levels in the organization and is able to utilize more formal dissemination techniques.

Inter-Organizational Communication by Other Means

Gatekeepers and Opinion Leaders are of course not the only means by which technology may be transferred between organizations. A number of other formal and informal mechanisms operate alongside of, and sometimes, in place of these two channels.

The Centralized Research Institute

Government sponsored research institutes have been established in many countries to perform R&D for particular industry, or often times for industry generally, These vary widely in organization and purpose but they usually supply technical consulting services, access to documentation, and often formal product or process development work.

The rationale for such institutions lies in the fact that industry comprising very small firms cannot afford to do its own R&D. The government, being interested in economic development and believing that the technological development of industry will contribute to that goal, supports R&D in the institutes. What is hoped is that the research institutes will serve as "gatekeeping organizations". That they will link industry to sources of technology and will develop technology themselves for immediate use by their client firms.

For the most part this strategy has proven a dismal failure. Several recent studies (Utterback, 1975; Allen, 1977b) show the research institutes as very poor sources of technology for industry. We, for example, conducted interviews in 75 firms in 12 industries in one small European country. Our goal was to determine the sources for new technology, which had been introduced into the firm at some point in the recent past. Individuals in each firm were asked to identify the most important change in product or process that had been introduced in recent years. Key individuals were then interviewed to determine how each of these cases came about. Despite the fact that this particular country funded three research institutes in support of the 12 industries, there was very little indication that these were at all helpful in either introducing the original idea or in solving any of the technical problems encountered later (Tables I and II).

The reasons for the general failure of the research intitutes are numerous and vary among contexts. They are all related, however, to our discussion in earlier sections of the organizational barriers to communication, and to the fact that few, if any research institutes are structured to deal with such problems.

Table I

Sources of Initial Idea Leading to Technological Change

Source	Proportion of Messages*
Research Institutes	1.4%
Other Firms	72.8
Government Departments; Universities; Trade Fairs; Industry Associations; Private Consultants	16.5
Documentation	9.3

* Seventy-three instances of technological change were based on 140 messages which originated outside of the firms.

Table II

Sources of Information Used in Solving Problems Related to Technological Change

Source	Proportion of Messages
Research Institute	2.8%
Other Firms	77.8
Government Departments; Universities; Industry Associations; Private Consultants	16.7
Documentation	2.8

An Analysis of the Bases for Communication Among Organizations

Since there is an enormous number of organizations involved with educational innovation in the United States, networking must necessarily involve people in many different kinds of organizations. Among these will be university departments, research institutes of various sorts and school systems, themselves. This is the system, through which technology is to be diffused. An analogous situation exists in many industries where there are many firms that support little or no R&D themselves, university departments that may be contributing to technologies relevant to those firms and sometimes even research institutes established to support the firms in the industry. This is particularly true in many small countries where the government takes extraordinary steps to support research institutes for the development of technology for industry.

The Irish System

A case of this sort exists in the Republic or Ireland where we have recently performed a communication network survey of the research and development community.

The techniques used in studying industrial firms were adapted to suit the condition of analysis at a national level (Allen & Cooney, 1973).

The questionnaire, itself, requested information on demographic variables, such as age, education, field of research activity and years of technical experience, but in addition information was obtained on each respondent's present and former employers both within and outside of Ireland, and on each respondent's communication activity at three levels: within his organization; within the country outside of his own organization; and outside of the country. Data such as these can be analyzed in many ways. The present paper is concerned

only with the flow of information into and among the various research institutions in the country. Once communication measurements as these have been made at an individual level it is a relatively straightforward task to aggregate them by specific organization, and to examine the relative strengths of communication bonds between organizations. This provides a measure of the extent to which technical and scientific information flows, via personal contact, from organization to organization or from sector to sector, within the country.

Each respondent was asked to report the frequency (once a month; once every six months; etc.) with which he maintained contact with those outside his organization, and the data were analyzed in terms of a high frequency network (once a month or more frequent) and a low frequency network (less than once a month, but at least once a year).

Most important for present purposes, each respondent was also asked to indicate how he had first met each of the individuals, with whom he maintained regular communication about scientific or technical matters.

The Development of Communication Bonds

It is one thing to say that communication between any two organizations or between sectors should be improved, but it is quite another thing to specify just how one would go about it. Fortunately, participants in the survey were asked (by means of coded categories) to indicate how they first met each of the individuals, outside their organization, with whom they regularly discuss scientific and technical subjects. There was a total of 1,282 such contacts for which respondents indicated the way in which the contact first came about. Of these 495, or 38.5% were with scientists or technologists in other countries.

Domestic Contacts

Of the remaining domestic contacts, 36% were the result of working relationships between individuals in different organizations that were in effect at the time of the study. Work relationships or project membership are a very strong determinant of communication patterns (Walsh & Baker,1972; Allen, 1977a; Gerstberger, 1971; Allen & Tomlin, in preparation). If communication is desired between any two organizations, or organizational entities, certainly one of the most effective techniques is to involve the two in a joint project or other effort. This is a fact that has been demonstrated widely, under many and varied conditions.

For present purposes, however, it might be more important to determine how those contacts, which were not required by the nature of the work, came about. These, it seems, are caused more often by people becoming acquainted through working together in the same organization. In such cases, the contact has either worked in the respondent's organization and then changed jobs; the respondent had formerly worked in the contact's organization; or both had worked in a third organization. Job mobility, to the extent that it exists, is a very important determinant of inter-organizational communication.

This remember is in a European context, where job mobility and the resulting potential for inter-organizational relations, in no way approaches the level commonly found in the United States.

Acquaintances made in the university are next in line of importance. These include professor-student relations as well as relations among former students. In a small country, such as Ireland, with a limited number of university departments in any field, one might expect that a reasonable number of scientists would, in any specialty, have known one another from university days. One would not expect such a strong influence from this source in a country the size of the United States.

Table III

Sources of Communication Contacts Other Than Those Stimulated by Current Working Relationship

(503 Instances)

Way in which contact was established	Proportion
Previously worked together in the same organization	29.9%
Met in university	20.5
Met through professional society membership or conference	18.6
Introduced by mutual acquaintance	9.7
Formerly had working relationship	4.9
Other	15.7

Professional society conferences and meetings rank fourth in importance. The effectiveness of this mechanism will vary with field or discipline. One would certainly not want to argue that the results found for Irish physical scientists should be extended to American educators. Nevertheless it is a potential stimulant of inter-organizational relations, and is of particular value to gatekeepers.

Introductions and former working relationships account for about 15% of the total. An important point, to be made here, concerns the difference between the number of communication contacts resulting from current work relations and the number from past work relations. The work-induced force to communicate is apparently very strong, but not terribly persistent.

Finally, the category 'other' in Table III includes a vast range of reasons, from the use of common facilitis to family relationships. The most common cited reason in this group, though, is that of having common research interests. Apparently, one member of the pair learns of the other's research, probably through the published literature, and then seeks more direct and continuing contact with the second party.

Influencing the Structure of Networks

The topic of "networking" in education is often criticized, because it is said that there is nothing that can be done to influence the development or restructuring of networks. This is not true at all. We are constantly influencing the structure of the networks in which we participate. The convening of the present conference has probably had a significant effect on the structure of several networks. People have met here for the first time, discovered common interests, and will remain in contact in the future.

Allen (1977) treats the topic of influencing network structure in considerable detail. The context is that of a research laboratory, where the development of

an effective internal communication network is critical to performance. Broadly speaking, there are three types of influence which he discusses:

1) the structure of the formal organization group and project assignments, reporting relationships, etc.
2) the structure of informal relations, friends, lunch partners, former project colleagues, etc.
3) the structure of the facilities, size, shape and relative location of buildings, etc.

Each of these has an influence on the formation of the internal communication network. But more importantly, each can itself be influenced in some way to change network structure, if that is desired. The formal organization can be modified to create different reporting relationships or different groupings of personnel. This in turn will affect the structure of communication in the organization. Personnel can be re-assigned within a stable organization structure, increasing the likelihood of informal bonds between different parts of the organization, thereby also increasing the probability of communication between those parts. Thus the existing network is changed. Finally, the architecture and relative location of buildings can be modified to influence the ease of contact among occupants. This has been shown to have a very strong effect on network structure. Allen (1977) details several examples of changes of this sort and measures their impact on networks.

The Irish research shows several examples of the way in which networks have been influenced by national policy. The awarding of foreign sabbaticals and internships certainly affected the likelihood of developing foreign contacts. Policies to attract emigre scientists have had a similar influence. The domestic network was similarly influenced by policies that encouraged or more often discouraged the migration of scientists between employing institutions.

So networks can be influenced in their structure. There is no reason to believe that educational networks will differ in this sense. Some of the forms of influence may differ, but the fact that networks can be developed or modified remains.

User-Supplier Relations in the Innovation Process

One final area of potential interest lies in the recent work of Eric Von Hippel (1976; 1977). In several studies of the innovation process in industrial goods, Von Hippel finds the customer's role to be a far from insignificant one. In fact, the locus of innovation resides very often in the user rather than the supplier organization.

The process operates in something like the following way. The need for a new type of production equipment or test instrument is first realized by the people who would eventually use such a product. Rather than approach an equipment supplier with their need, they will very often design and even fabricate a working model themselves. In other words, they take on many of the activities normally associated with the innovation process. The supplier organization learns of the new product, only if a greater number of items are required than can be produced reasonably by the users, or if their sales force are sufficiently astute to uncover such instances of user innovation. The supplier's contribution is then in the form of final engineering and production technology, which bring the innovation to the point where it can be economically produced in the desired quantities.

There is some further evidence from the Von Hippel work that in certain industries, both user and supplier firms are segmented, with the more specialized or technically sophisticated users being supplied by a few small firms, who are willing to be responsive to their special needs. The majority of the

market is served by a smaller set of large firms interested in quantity production. The flow of technology in such a situation is from the sophisticated user to the smaller supplier, and eventually if the market appears sufficiently large to the larger suppliers through licensing, acquisition or other means.

Technology is added at each stage, but the principal breakthroughs occur at the initial stage, in the user organization.

This, of course, implies a very different set of marketing and R&D strategies for supplier firms. The normal market research feeding internal research and development model is no longer the most effective and can lead to unnecessary costs. In fact, the suppliers can often push a major portion of their R&D costs off on their users, and there is evidence that in certain industries this is in fact what is done.

In a very large, highly decentralized educational system with many highly sophisticated users of technology there is a potential for the same sort of pattern. What successful supplier firms, in Von Hippel's studies, do is search out user developed innovations and merely add their layer of technology to make them generally acceptable. Agencies which will search out user innovations and then add the necessary technology to adapt them to more general use might make a significant addition to the diffusion of educational technology.

REFERENCES

Allen, T.J. (1977a) Managing the Flow of Technology. Cambridge, MA.: The M.I.T. Press.

Allen, T.J. (1977b) Transferring Technology to the Firm: Report on a Study of Irish Industry. M.I.T. Sloan School of Management Working Paper

Allen, T.J. (1970) Communication in the R&D laboratory. R & D Management, Volume 8.

Allen, T.J. (1966) The performance of information channels in the transfer of technology. Industrial Management Review, Volume 8.

Allen, T.J. (1964) The Use of Information Channels in R&D Proposal Preparation, M.I.T. Sloan School of Management Working Paper, No. 97-64.

Allen, T.J. and S.I. Cohen (1969) Information flow in research and development laboratories. Administrative Science Quarterly, 14, 12-19.

Allen, T.J. and S. Cooney (1973) Institutional roles in international technology transfer. R & D Management, 4, 41-51.

Allen, T.J. and B. Tomlin (in preparation). The Development of Communication Networks in a Geographically Dispersed R & D Organization.

Allen, T.J., M.L. Tushman and D. Lee (1977) Modes of Technology Transfer as a Function of Position in the R&D Spectrum, M.I.T. Sloan School of Management Working Paper, No. 918-77.

Baker, N.R., J. Seigmann and A.H. Rubenstein (1967) The effects of perceived needs and means on the generation of ideas for industrial research and development projects. IEEE Transactions on Engineering Management, 14, 156-162.

Carlson, (1964).

Coleman, J.A., E. Katz and H. Menzel (1966) Medical Innovation: A Diffusion Study, New York: Bobbs-Merrill.

Frost, P. and R. Whitley (1971) Communication patterns in a research laboratory, R&D Management, 1, 71-79.

Gerstberger, P.G. (1971) The Preservation and Transfer of Technology in Research and Development Organizations, unpublished Ph.D. dissertation, M.I.T. Sloan School of Management.

Hagstrom (1965) The Scientific Community, New York: Basic Books.

Katz, E. (1957) The two-step flow of communication: an up-to-date report as an hypothesis, Public Opinion Quarterly, 21, 61-78.

Katz, E. and P.F. Lazarsfeld (1955) Personal Influence, Glencoe Illinois: Free Press.

Lazarsfeld, P.F., B. Berelson and H. Gaudet (1944) The People's Choice, New York: Columbia University Press.

Rogers, E.M. and F.F. Shoemaker (1971) Communication of Innovations: A Cross-Cultural Approach, New York: Free Press.

Taylor, R.L. and J.M. Utterback (1975) A longitudinal study of communication in research: Technical and managerial influences. IEEE Transactions on Engineering Management, 22, 80-87.

Utterback, J.M. (1975) The role of applied research institutes in the transfer of technology in Latin America. World Development, 3, 665-673.

Von Hippel, E.A. (1977) Has a customer already developed your next product? Sloan Management Review, 18, 63-74.

Von Hippel, E.A. (1976) The dominant role of users in the scientific instrument innovation process. Research Policy, 5, 212-239.

Walsh, V.M. and A.G. Baker (1972) Project management and communication patterns in industrial research. R&D Management, 2, 103-109.