Structural Clarity of Interdisciplinary Teams: A Research Note*

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Previous studies of scientists in formal organizations have stressed the conflict between the scientist's professional need for autonomy and the organization's need for an efficient—often bureaucratic—formal structure. In this paper the importance of a clearly articulated formal structure (that need not be bureaucratic) in interdisciplinary research teams *is discussed as a necessary condition for the development of adequate communication among team members. The authors argue that without a basic formal structure that is clear to all members, effective interaction and communication will not take place. Findings from a study of one interdisciplinary team are presented as illustrative of the ideas linking clarity of formal team structure, status problems, and interaction and communication within the team.*

INTRODUCTION

Interdisciplinary research teams present special problems of coordination and productivity, distinct from the problems faced by individual scientists in organizational settings (Kornhauser, 1962; Pelz & Andrews, 1966; Glaser, 1964). Unfortunately, little work has been done on characterizing the variables of team structure that affect team coordination and productivity. The usual assumption made by managers of research organizations that utilize teams is that by acquiring professional scientists of high quality and obtaining the necessary resources, productivity can be assured. Recently, Steck and Sundermann (1978) have

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commented on the importance of cooperation to the success of interdisciplinary teams. The first step in achieving cooperation, however, is to achieve a high level of communication.

Although many writers have commented on the importance of communication as a necessary condition for productivity in scientific teams (Thompson, 1961; Vollmer & Mills, 1966), the problems involved in fostering communication among team members are often underestimated. These problems are intensified in interdisciplinary research teams. Interdisciplinary research has been defined by Newell (Note 1) as "those [research] situations in which the problems or issues posed require that a group with various disciplines represented integrate their approaches. An interactive joint effort is required to reach a solution." Interdisciplinary teams present special problems since professional norms, standards, and vocabulary are not always transferable across disciplinary boundaries. Thus, even when contact among team members is possible, communication may be inhibited.

Recent papers by Kruse et al. (Note 2, Note 3) have focused on status problems in interdisciplinary teams. The unequal statuses of team members may contribute to communication problems. It is our contention that a lack of clarity in the structuring of interdisciplinary teams also leads to difficulties in communication among team members. The formal structure of any organization provides the framework, or blueprint, for the functioning of that organization.

It is the existence and clarity of a minimal level of formal structure (the blueprint, the basic foundation) in interdisciplinary research teams that we wish to focus on here. We define a team's formal structure simply in terms of its divisions of labor and systems of evaluation and authority. The clearer the formal structure of the team (i.e., the extent to which each team member can readily identify the team's division of labor and system of evaluation and authority), the more likely the team will engage in the necessary level of communication to ensure an interactive joint effort. In this analysis, we focus on three main concepts: (1) clarity of formal team structure, (2) status inconsistencies and ambiguities, and (3) interaction and communication within the team. Our main thesis is that without a clear, formal team structure, and where status problems exist, interaction and communication will be impaired.[1]

THE STUDY

Several interdisciplinary research teams were studied by researchers from the Laboratory for Social Science Research at Stanford University from 1975 to 1978. The ideas reported in this paper come from an intensive study of one team. We present these findings *as illustrations* of our ideas concerning clarity of structure, status, and communication. The team discussed here is composed of nine scientists representing six different fields. Five team members hold bachelor's degrees; three have master's degrees, and one is a Ph.D. The team is situated within a large government bureaucracy, and all team members have formal ties to various divisions within the bureaucracy. This particular team is similar to the other teams studied in terms of size, number of disciplines represented, degree mix, government client, and length of team operation.[2] Furthermore, compared to the teams represented by a regional survey of 150 principal investigators of fairly large grants from the National Institutes of Health and the RANN program of the National Science Foundation (see Cohen, Kruse & Anbar, 1982), this team fell slightly below the median in terms of team size and at the median of the number of

disciplines represented for multidisciplinary teams.

Formal structure of the team: clarity of the evaluation system

There are distinctly observable divisions of labor within most teams with respect to procedures necessary for the smooth functioning of the team, including performance evaluation processes. Following Dornbusch and Scott (1975), the evaluation process consists of four components: allocating, criteria setting, sampling, and appraising. The holders of authority rights in each of these components may or may not overlap, but each occurs as a distinct part of the evaluation process. We deal here with three of these: allocating, criteria setting, and appraising.

In this section we will consider the level of agreement among team members concerning who has been allocated which tasks to perform. The more agreement among team members concerning task allocations, criteria setting, and evaluation rights, the clearer the formal structure. We would expect, then, that a lack of clarity in any one of these three areas is indicative of an unclear formal structure. Table 1 summarizes our interview data on these three aspects of team structure.

Task allocation rights

Team members were asked the following questions concerning task allocations:

- Generally, who has the *right to assign* you tasks to perform?
- Who *usually* assigns you tasks to perform?
- To which members of the team do you have the right to assign tasks?
- To whom do you usually assign tasks?

In most cases, the right to assign tasks coincided with the actual assignment of tasks. Column 1 of Table 1 represented the actual allocation of tasks to team mem-

Table 1
Clarity of Team's Structure

	1	*2*	*3*
Team Member	*Allocated Tasks by:*	*Criteria Set by:*	*Evaluated by:*
PE	PI	PI	PI
A	PE E*	PE	PE*
B	PE	PE	PE* E*
C	PI D	PI	PI
D	PI PE*	PI	_ _ _
E	PI PE*	organization standards	PI PE*
F	PI PE*	PI	_ _ _
G	PI	discipline's standards	PI
Proportion of agreements	.69		.50

PI = Principal Investigator
PE = Project Engineer
* = Reported only by Allocator or Evaluator

bers by the principal investigator (PI), the project engineer (PE), or other team members. The initials of task allocators in Column 1 can be interpreted as agreement between team member and allocator concerning task allocation rights. Initials of allocators with asterisks (*) signify that only the allocator reported the right to assign tasks to that team member; the team member did not recognize the allocator's right to assign him tasks.

The proportion of mutually reported task allocations rights to the total number of task allocations reported gives us a rough measure of the clarity of the team's structure on the task allocation dimension. In this team there is 69% agreement on task allocation rights.

Agreement on responsibilities

We also compared the PI's description of each team member's responsibliities with each individual's assessment of his own job as a team member. We found that all team members described their own responsibilities exactly as the team leader had described them with one exception—E. This particular inconsistency had an effect on several other aspects of the team's formal structure, including criteria-setting rights, allocating rights, and evaluating rights. Team member E reported to us that he considered one of his major responsibilities to be the exercise of performance evaluation rights over several team members. The PI did not mention evaluation of other team members as part of E's responsibilities.

When team members were asked about the responsibilities of their fellow team members, the level of agreement falls considerably. Forty-one percent of the team's responses to questions concerning who does what on the team and how important is each individual to the team's success consisted of "don't know's." Obviously, the lack of knowledge concerning team responsibilities seriously questions the clarity of the team's division of labor.

Criteria-setting rights

To hold criteria-setting rights over other team members means that you must (1) determine the salient task properties used in making evaluations; (2) assign relative weights to the different properties under consideration; and (3) determine the standards against which the performance will be measured and develop the transformation rules for changing values on performance dimensions into scores on an evaluative scale (Dornbusch & Scott, 1975). To determine who held criteria-setting rights over whom within the team, the following questions were asked:

- In order to evaluate how well or poorly a person is performing, standards must be set to define what is satisfactory or unsatisfactory even though these standards may be vague. A standard, then, is the level that is set to distinguish good performance from poor performance. Who sets the standards for judging how well or poorly you are performing?
- Do you set the standards for the formal, professional evaluations of the people you formally, professionally evaluate?

Column 2 of Table 1 summarizes the team members' responses to the first question. The only individuals named as criteria setters were the principal investigator and the project engineer, the two most important members of the team. Team member E's response that his performance criteria are equivalent to standards common throughout the bureaucracy indicates he is more organizationally oriented than the rest of his team members. In contrast, team member G's response that he takes his standards from his discipline indicates both

his high level of professional orientation and his low level of team involvement.

Only the project engineer and team members C and E responded to the second question concerning criteria setting. The project engineer, whom two team members named as setting the criteria for their performance evaluations, stated that he did *not* set the standards for anyone's professional evaluations and that all standards were organizational standards. Two other team members stated that they did, in fact, hold criteria-setting rights, but none of the team members mentioned them as either criteria-setters or significant evaluators. There is apparently a considerable amount of inconsistency and a lack of clarity concerning who is involved in these evaluations.

Performance evaluation rights

The last of the three aspects of formal structure to be examined here is the clarity of performance evaluation rights.

Evaluation rights refer to the right to actually appraise a performance, assign an evaluation to it, and communicate that appraisal to the team member. All team members were questioned about formal evaluations. To discover who formally evaluates whom, the following questions were asked:

- Whose evaluations of how well or poorly you are performing help to determine or influence your formal professional evaluations?
- Do your evaluations of how well or poorly others on your team are performing help determine or influence anyone's formal professional evaluations? If yes, who?

Column 3 of Table 1 presents the system of formal appraisal rights in the team. Four team members responded to questions about formal evaluations by saying, "Formal evaluations do not occur within this team or this organization." Initials of evaluators without asterisks can be interpreted as agreement between the team member and the evaluator concerning evaluation rights. Initials with asterisks indicate that only the evaluator claimed that right. Again, the higher the proportion of mutually reported evaluation rights to the total number of reported evaluation rights, the higher the level of clarity concerning the team's formal structure. For performance evaluations, this team has a clarity rating of .5. Evaluations are apparently even more unclear than task allocations. Furthermore, the project engineer and team member E insisted that these relationships only represent possible influence on formal evaluations, and that formal evaluations do not actually occur within the team. In summary, it appears that the formal structure of this research team is not very clear to most team members.

The next section will deal with status problems within the team. According to most studies of small groups, both in the laboratory and in the work setting, individuals brought together to work on a team problem will organize themselves along status or prestige lines, whether or not a formal structure is provided initially (Bales & Strodtbeck, 1951; Heinicke & Bales, 1953; Bales, 1953; Bales & Slater, 1955).

Status problems within the team

Two types of status problems will be considered here: status inconsistencies and status ambiguity. Status inconsistency occurs when a team member's internal status (status accorded him within the team on the basis of his importance to the team's effective functioning and/or success) is not consistent with his external status (defined as perceptions of the individual's standing in the scientific community outside of the organization). As Kruse et al. (Note 2, Note 3) point out, such external-internal inconsistency can be a source of tension

and discomfort for such individuals, and this in turn may become a source of tension for other team members, thus blocking interaction and communication within the team.

Kruse and coworkers have also discussed how the problem of status ambiguity can frequently occur in interdisciplinary teams. On the internal status dimension, it may be difficult for team members from different disciplines to determine whose contribution to the team project is most important, or whether the functions performed by fellow team members can be easily filled by others. This is especially likely in teams where some members do not know what other members do, as is the case here. Likewise, ambiguity along the external status dimension can be common in interdisciplinary teams. For example, how does a physicist evaluate the external status or prestige of an economist or a sociologist? Or, how does a biologist evaluate a physicist? Both kinds of ambiguity can make it difficult for scientists to deal with each other, as expectations of appropriate deference and dominance behavior will not be commonly shared.

In our study we asked team members to indicate on a scale from one to ten their opinion of other team members in terms of (1) how much the loss of each member would impair the team's chances of success (internal status), and (2) the general standing of each team member in the scientific community outside of their own organizations (external status). Higher scores were assigned to individuals whose loss would have a greater impact and whose external standings were higher. Average scores were converted into rank orderings of internal and external status and are presented in Table 2.

Table 2
Disciplinary Affiliation, Internal Status, External Status, and Interaction

Team Member	*Discipline*	*Internal Status*	*External Status*
A	Mechanical Engineering	9	9
B	Physics	6	7
C	Aerodynamics	8	5
D	Aerodynamics & Computers	3	2
PE	Mechanical Engineering	2	6
E	Physics	6	8
F	Aeronautical Engineering	4	4
G	Geophysics	6	3
PI	Reentry Specialist	1	1

rho = .67

Team Member	*Ranking on Number of Team Members Interacted With*
A	5.5
B	5.5
C	8
D	5.5
PE	2
E	5.5
F	3
G	9
PI	1

Many individuals did not know all the other team members well enough to evaluate what effect their loss would have on the team's chances for success. Only two individuals, the project engineer and one of the original core scientists, could evaluate every team member. There were also many individuals who lacked sufficient knowledge of some team members to evaluate their general standing in the scientific community. Thus, given the lack of colleague-familiarity in this team, both with respect to internal and external status, it is safe to characterize this team as a social setting with some degree of status ambiguity. Status ambiguity occurs when individuals are unsure of their position within the team. We found there were several team members who could not define their position in the team in unambiguous terms. Consequently, it is doubtful that an informal network would develop upon which to base collegial communication and interaction.

The internal prestige rankings (see Table 2) of team members give higher ranks to the principal investigator, the project engineer, and the two core investigators who have been with the experiment since its planning stages. The next highest rank went to the most recently added core investigator and lower ranks were assigned to the support personnel.

When considering external status rankings, the highest rankings go to the principal investigator and the three core investigators. The project engineer ranks considerably lower in external status than in internal prestige. For the sake of comparison, a rank order correlation index (Spearman's rho) was computed between internal and external status, yielding a score of .67. There is a fairly strong positive relationship, therefore, between perceptions of internal and external status. There are at least three team members, however, whose rankings on these two dimensions differ by at least three ranks. Both C and G hold higher levels of external prestige (a difference of 3 ranks), and the project engineer is much more important internally than externally (a difference of 4 ranks). These three team members occupy positions of status inconsistency in that their internal prestige significantly differs from their prestige in the greater world of science (see Kruse et al., Note 2, Note 3). Settings characterized by status inconsistency are likely to produce social strain or tension, and can result in a decrease in the motivation of those individuals involved for communication or interaction with others in the settings as a means of reducing their feelings of stress or strain. Given this situation, we expect that there may be problems in the team concerning the participation, interaction, and exchange of ideas involving these three team members.

Interaction and communication

We have attempted to document the absence of a clearly articulated, formal team structure. Earlier we argued that in the absence of structural clarity, sufficient communication among team members would not take place. We now present evidence on the interaction and communication among team members.

Given our nine-member team, there are n(n-1)/2 possible interaction pairs, or 36 pairs. Of these 36 possible interaction situations, only 15, or less than half, ever took place. This is a measure of whether individuals have ever interacted and does not take frequency of interaction into consideration. Furthermore, seven of these 15 interaction pairs involved the PI. Clearly, other team members were not interacting with each other.

Another measure of team interaction and communication is the reported frequency and importance of team meetings. Though we asked no specific question regarding this matter, a number of team members responded to the interaction question by

telling us that team meetings were held to review the work of the independent contractor responsible for constructing instruments necessary for the project. During the time in which we investigated the team, these meetings were very infrequent, their scheduling dictated by the independent contractor.

Related to the level of communication on a specific team is the generation and receptivity of ideas. Two team members reported that they had no ideas for change in team objectives or activities up to the point of the interview (at least 18 months after the team was formed). Among those who have had ideas, two team members communicated their ideas occasionally, two frequently, and two almost always. All team members, except F, reported that they communicate their ideas in private conversations only. F reported that he communicated his ideas both in private conversations and in team meetings.

One interesting aspect of idea discussion is the fact that there is little agreement among team members on who talks with whom. A, B, and the project engineer agree that the former two consult with the latter. The project engineer, however, does not agree with their assertions that he talks with them about his ideas. The only interaction relationship in which there is total agreement is that of the project engineer and team member F.

Another way to approach the issue of interactions and idea discussions is to look at the effect of disciplinary affiliation, internal status, and external status on communication. Table 2 contains information on these three characteristics for the nine team members, as well as information on interaction and idea discussion. We find there is no relationship between external status and level of communication or between disciplinary affiliation and level of communication. If we compare rankings on internal status and level of communication, we find that the number 1, 2, and 4 individuals on internal status are the number 1, 2, and 3 people on number of team members interacted with. This effect could be a result of the fact that No. 1 is the team leader, No. 2 is the project engineer, and No. 4 holds a position of authority within the organization's bureaucratic hierarchy. As we had expected, two status-inconsistent team members, C and G, are the least tied into team interaction.

The team leader and the project engineer thus appear as the central members in the interaction pattern of the team. This is probably because of their responsibility for the different phases of the total team effort and is associated with their centrality in the team structure. Individuals with positions in either the formal structure or the status structure that are not clearly defined accordingly have low levels of interaction with other team members.

SUMMARY AND CONCLUSIONS

This low level of interaction has apparently characterized the team since the beginning of its work on the experiment, even in the idea-formation stages. What little communication there was among experimental-phase people was always channeled through the team leader. The team leader's centrality in the team's interaction network is not surprising, but the "non-team" character of this interdisciplinary team is.

Whereas it could be argued that any sort of formal organization seems to hamper the activity of individual scientists, the lack of all structure, both formal and informal, in a scientific research team results in a dangerously low level of communication and interaction. Scientific research teams cannot function successfully if team members do not share ideas and

criticism. If the team's formal structure is not sufficiently clear, the members are not likely to spend the extra time and energy needed to construct a workable informal structure. This is not to say that teams need a rigidly bureaucratic structure to function. The authority and evaluation processes must be clear, however, so as to provide a basis for the smooth functioning of the team. Some minimal level of structure is a necessary condition for communication in interdisciplinary teams.

This brief sketch of one interdisciplinary research team really presents only one cell of a four-fold theoretical table, in which both a lack of clarity in team structure and status problems are present, resulting in a low level of communication and interaction. The other three cells need to be investigated so that we can better explicate the relationships between these three variables. When structure (as we have defined it) is clear but status ambiguity or inconsistency exists, what effect is there on communication levels? What if internal and external status are consistent but the division of labor and the evaluation system are ambiguous? Exactly how does organizational structure and status structure interact to affect communication? Finally, it would be helpful to explore empirically the relationship between team structure, status problems, team communication, and team productivity. This question requires the development of measures of productivity that are meaningful to team members and to social scientists who wish to study scientific teams. Such a research undertaking would also necessarily require access to a number of a research teams and a sufficiently long-term project-life that would allow for observation of team outcomes. Although the investment of time and money for such a project would be considerable, we expect the outcomes would more than justify the expense.

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NOTES

1. It is important to note that this argument does not necessarily conflict with the generally accepted notion that bureaucratic structures are dysfunctional settings for scientific work (Pelz & Andrews, 1966; Kornhauser, 1962). A clearly articulated formal team structure need not imply bureaucratization and all of the well-known dysfunctional aspects of bureaucracies (Merton, 1949). A bureaucracy takes Barnard's (1968) simple principles of formal structure and complicates them considerably. The division of labor is highly differentiated; the hierarchy of authority is elaborate, and the rules for moving up and down the hierarchy are rigidly pre-established by the organization; formal rules control the behavior of organizational members; procedural specifications determine the techniques members use in dealing with whatever situation they encounter; and impersonality pervades the entire structure, both in dealings with organizational members and with outsiders.

2. For brevity's sake, we have chosen to focus on only one team in this paper, and this was the last team we studied. Although we investigated status and organizational problems in other teams, the instruments for data collection on evaluation system processes were not developed until later in the study's funding period.

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