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Sociotechnical Systems: A North American Reflection on Empirical Studies of the Seventies[1]

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This paper reviews the development of sociotechnical systems theory and research over the past 30 years, paying particular attention to the evolution of the paradigm in North America during the past decade. Elements of sociotechnical systems theory discussed here include the conceptualization of social systems, technical systems, and open systems, joint optimization, organizational choice, variance control, boundary location, support congruence, quality of work life, and continuous learning. A review of 134 experiments is then summarized, indicating which features of sociotechnical systems design are used most frequently, and which in turn are associated with reported success on a number of critical outcome dimensions such as productivity, costs, quality, and satisfaction. An unexpected finding of this review was that while sociotechnical system experiments have been extremely successful overall, the number of experiments involving technological innovation or change is relatively small; moreover, from the results achieved in these experiments, it is obvious that we still have much to learn regarding the design of technical systems for joint optimization. Methodological issues and areas in need of further research are explored.

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Sociotechnical system interventions are organization development techniques that typically involve the restructuring of work methods, rearrangement of technology or the redesign of organization social structures. The objective is to optimize the relationship between the social or human systems of the organization and the technology used by the organization to produce output. (Pasmore & Sherwood, 1978)

INTRODUCTION

Since the classic studies of the British coal mining industry were first reported by Trist and Bamforth in *Human Relations* in 1951, interest in sociotechnical system methods of work restructuring has grown almost geometrically. Today, as evidence of that interest, there are over 100 published reports of sociotechnical system experiments and at least as many theoretical statements to guide the potential user in application. Several reviews of the experimental literature have been undertaken recently, including those by Taylor (1975a, 1977), Friedlander and Brown (1974), Walton (1979) and Srivastva, Salipante, Cummings, Notz, Bigelow, and Waters (1975). While the reviewers are in accord regarding the effectiveness of sociotechnical issues besetting the comparison of work restructuring accounts, none have succeeded in reviewing the theoretical and experimental literature simultaneously. Such a comparison would indicate the extent to which various tenets of sociotechnical system theory are being regularly applied in practice and which are being underutilized; furthermore, one would be able to discern which features of the theory are associated with positive outcomes and which provide a useful conceptual frame but little more. Given the increasing rate of sociotechnical system experimentation, it seems appropriate at this time to provide an overview of the entire paradigm as it exists today in order to point out the critical questions which should be asked by researchers and practitioners in the future.

Another reason for the timing of this review is our informal observation that while the number of experiments being undertaken is increasing, the number of published accounts of efforts is decreasing. This signifies to us that sociotechnical system approaches to work restructuring may have moved through the stages of introduction, experimentation, and evaluation into the stage of general acceptance and implementation. While the increased application of sociotechnical methods is encouraging, the decrease in associated research is a cause for concern; for as other organizational improvement methods have become less interesting to scientists, they have been applied more indiscriminately and with less success than in previous attempts. Job enrichment, MBO, sensitivity training, and matrix organization design have all followed this route to some extent. Beyond the indiscriminate application of these methods by well-meaning but relatively unguided laymen, little scientific evaluation of later efforts take place. Unfounded rumors based on informal observations begin to spread, citing problems or outright failures with an approach; soon, the paradigm is all but abandoned in search of "new and better" approaches.

We have observed an increasing number of organizations attempting sociotechnical system change without outside guidance; we have also witnessed more failures or desertions from these efforts than have ever found their way into the literature. Hence, while this review is intended to summarize what we have learned about sociotechnical system approaches from past efforts, it is also a call for continued research on the process of implementation and its attendant pitfalls. Only through continued attention from the scientific community will the benefits derived from our knowledge of sociotechnical system methods be preserved; and given the results that sociotechnical system interventions have achieved in improving the quality of working life and organizational effectiveness, it would be sad indeed to see sociotechnical systems fall by the wayside as "just another fad."

In undertaking this review, we were forced to recognize that sociotechnical system theory has become eclectic, drawing on a wide array of behavioral science theories and techniques. As a result, we have had to make difficult decisions regarding what should and should not be included here. We have narrowed the theoretical focus of the review to what we consider to be the major themes of the sociotechnical approach; we have excluded material on theories of leadership, group dynamics, motivation, organizational structure, and reward systems although few would deny that they are pertinent to the study of sociotechnical systems.

What we will provide is an overview of the literature which has been directly associated with sociotechnical system thinking and practice. We will begin the review with a discussion of the literature relating to sociotechnical system theory; we will then draw from the theory features of sociotechnical system design which may be used to analyze sociotechnical system experiments. Over 130 experiments have been assessed to provide data for the analysis we shall present, which in turn will lead to the statement of conclusions regarding needs for further research in the field.

SOCIOTECHNICAL SYSTEMS THEORY

The term "sociotechnical system" was coined by Trist (Trist & Bamforth, 1951; Trist, Murray, Higgin, & Pollock, 1963) to describe a method of viewing organizations which emphasizes the interrelatedness of the functioning of the social and technological subsystems of the organization and the relation of the organization as a whole to the environment in which it operates. Put simply, the sociotechnical system perspective contends that organizations are made up of *people* that produce products or services using some *technology,* and that each affects the operation and appropriateness of the technology as well as the actions of the people who operate it (Trist, 1978; Emery and Trist, 1965; Emery, 1959; Butera, 1975; Trist et al., 1963). Trist and Bamforth (1951) made the following observation during their studies of the British coal industry:

> So close is the relationship between the various aspects that the social and psychological can be understood only in terms of the detailed engineering facts and the way the technological system as a whole behaves in the environment of the underground situation (p. 3).

The principle of *joint optimization* (Emery, 1959), which is the goal of sociotechnical system intervention, states that an organization will function optimally only if the social and technological systems of the organization are designed to fit the demands of each other and the environment. In contrast, many techniques aimed at improving organization effectiveness concentrate on the social system exclusively, taking the technology of the organization as constant and unchangeable (Friedlander & Brown, 1974). Even the technique of job enrichment (Paul, Robertson, & Herzberg, 1969; Ford, 1969; Herzberg, 1968; Herzberg, Mausner, & Snyderman, 1959), which is closely related to the sociotechnical system approach, assumes that the answer to increased organization effectiveness lies primarily in increasing employee motivation.

While viewing the social system as the target for change in an organization is useful for some purposes, it is too narrow to explain or predict much of organizational performance (Pasmore & King, 1978; Pasmore, 1978). Sociotechnical system interventions differ from socially focused methods in that they do not accept technology as given. Instead, arrangements of people and technology are examined to find ways to redesign each system for the benefit of the other in the context of the organizational mission and needs for survival. The result of sociotechnical system intervention, therefore, is to bring to bear powerful forces that shape behavior in ways that improve organizational performance while enhancing the quality of working life.

A number of writers have contributed to the development of sociotechnical theory (Trist & Bamforth, 1951; Trist et al., 1963; Rice, 1958; Emery & Thorsrud, 1969; Emery, 1959; Miller, 1959; Trist, 1967, 1977, 1978, 1981; Davis & Trist, 1974; David, 1977; DeHaan, 1976; Taylor, 1975b; Cotter, 1977; Cherns, 1976; Walton, 1972, 1975, 1978, 1979; Cummings, 1976; Cummings & Srivastva, 1977; Pasmore, 1978, 1979;

Pasmore & Sherwood, 1978; Pasmore, Srivastva, & Sherwood, 1978; Hertog, 1979; Herbst, 1974; Osbaldeston, 1976; Jenkins, 1978; Hill, 1971; Haberstroh, 1965; Cooper & Foster, 1971; Cooper, 1974; Thorsrud, 1977; Duckles, Duckles, & Maccoby, 1977; Tichy & Nisberg, 1976).

The characteristics of sociotechnical systems described by these authors are in many cases similar; some of the more widely discussed characteristics are reviewed below.

The Social System

The social system of an organization is comprised of the people who work in the organization and the relationships among them (Trist & Bamforth, 1951; Emery, 1959, 1962; Trist et al., 1963; Taylor, 1975a; Cummings & Srivastva, 1977; Pasmore, 1978; Pasmore, Srivastva, & Sherwood, 1978; Archer, 1975; Cherns & Wacker, 1976). More broadly, the social system includes the reasons that organizational members choose to work in the organization, their attitudes toward it, their expectations of it, patterns of supervisory-subordinate relationships, skill levels of employees, and the nature of the subgroups within the population. In short, the social system encompasses all that is human that members of an organization bring with them to work. The sociotechnical system theorist contends that identifying the needs that people bring with them to the workplace, and incorporating means of meeting those needs through the design of the technology and the work itself, is the surest way of directing the efforts of organizational members toward organizational goals.

More will be said of how to arrange technology to meet human needs shortly; at this time, we shall simply note that instruments which have been used to assess social systems may be found in Cherns and Wacker, 1976; Atchison and Lefferts, 1972; Cohen and Turney, 1978; Emington, 1978; Mobley, Hand, Baker, and Meglini, 1979; Friedlander, 1966; Brown, 1969; Ford and Borgatta, 1969; Aram, Morgan, and Esbeck, 1971; Steers, 1977; Aldag and Brief, 1975; Hackman and Oldham, 1980; Lodahl and Kejner, 1965; Taylor, 1976, 1977; and Taylor and Bowers, 1972. Which of these instruments is chosen will depend on the nature of the issues perceived to be relevant to the study of the organization under consideration; one observation we shall make is that how one chooses to assess the organization will determine the changes recommended. To the extent that diagnostic methods diverge, it is difficult to compare the adequacy of different sociotechnical system diagnoses, and hence the possible causes for successes or failures of different experiments. The instruments used to diagnose the organization in preparation for sociotechnical system intervention are rarely identified in accounts of interventions; the use of more uniform assessment tools and better reporting of the initial diagnoses would help a great deal in understanding the different outcomes of comparable interventions.

The Technical System

The technical subsystem of an organization consists of the tools, techniques, procedures, skills, knowledge, and devices used by members of the social system to accomplish the tasks of the organization (Trist & Bamforth, 1951; Trist et al., 1963; Cummings & Srivastva, 1977; Cooper, 1974; DeHaan, 1976; Emery, 1959; Miller, 1959; Rice, 1958; Emery, 1962, 1975; Faunce, 1958; Fullen, 1970; Taylor, 1971, 1975a, 1978; Rousseau, 1979; Woodward, 1958; Thompson & Bates, 1957; Fadem & DeHaan, 1976; Meissner, 1969). Historically, sociotechnical system analysis has been applied primarily to organizations employing physical technologies. White collar and service-oriented organizations have been studied only infrequently (Pasmore, Srivastva, & Sherwood, 1978; Taylor, 1977; Bostrom & Heinen, 1977; Macy & Jones, 1976). In either setting, the technological configuration chosen by organization designers constrains the operation of the social system by shaping the behaviors required to operate it. The level of variety, challenge, feedback, control, decision-making, and integration provided for social system members is largely a function of the way in which the technology is arranged (Fullen, 1970; Davis & Taylor, 1979; Davis, 1979). Figure 1 indicates these impacts of technology on the organization and its members.

The most direct impact of technology is upon organizational productivity; this is not surprising, since organizations acquire technology to increase the speed and efficiency with which inputs can be transformed into outputs. In addition however, the technology also affects the location of workers, the motions required to operate it, and the behaviors required to keep the entire system running smoothly. Second-order effects emerge because of the need to coordinate the activities of those operating the technology. As soon as some are designated to manage while others are designated to operate the technology, roles and relationships develop; along with the roles and relationships come the attitudes people develop about the organization and the implicit psychological contract they develop with it which states how much freedom will be exchanged for the rewards received. Although it may not be immediately apparent to organizational designers, the choices they make about technology will affect who will be hired to operate the technology given the skills required; furthermore, as the

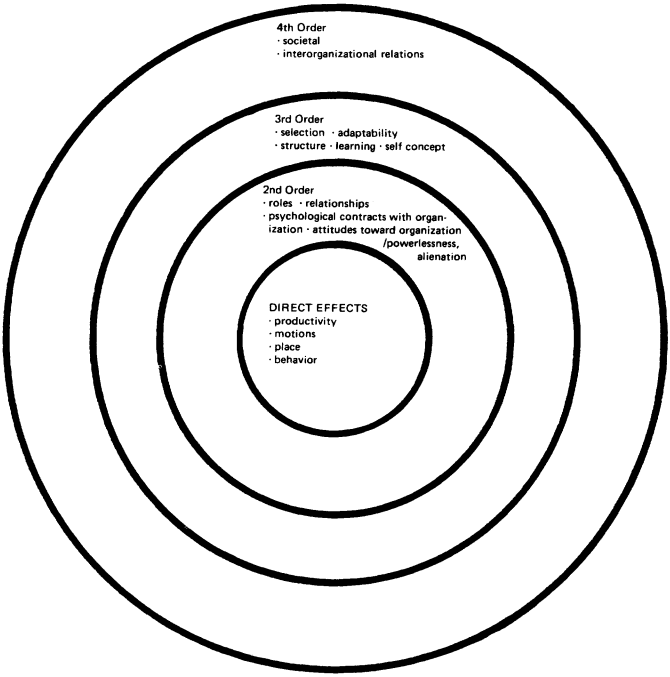

Fig. 1. The impact of technology on behavior.

structure of the organization solidifies according to skill levels, people begin to develop self-concepts in line with the way they are treated. To the extent that the organization stresses the value of the individual and provides learning opportunities for continued growth, the organization will remain adaptable over time; to the extent that the structure of the organization becomes stable and little movement within it is encouraged, the organization becomes less adaptable. Finally, as organizations develop similar patterns due to the technology they employ, interorganizational and societal relations will be influenced by the way the organizations are run and compete with one another.

It is the contention of sociotechnical system theorists that organizational designers constrain themselves unnecessarily in the choices that they make regarding the technological systems, and tend to overlook opportunities to redesign technologies to meet the needs of people. Nevertheless, as will be noted, relatively few sociotechnical experiments actually involve technological changes; instead, most concentrate on rearranging the social system around an existing technology in order to approximate joint optimization.

Open System Perspective

Organizations must interact with their environments to survive. They must import resources in the forms of labor and material, and produce some product or service which can be exchanged for additional resources. As a result, if organizations are to exist over time, they must be capable of adapting to changing environmental conditions. The open system perspective implies the need to examine transactions with the environment, maintain contact with environmental changes, and build adaptability into the organization to respond to both anticipated and unanticipated change (Clark & Krone, 1972; Haberstroh, 1965; Jayaram, 1976; Emery & Trist, 1965; Cummings & Srivastva, 1977; Emery, 1959; Butera, 1975; Davis, 1977). As organizational environments become increasingly turbulent and unpredictable (Emery & Trist, 1965; Davis, 1977) the need to ensure flexibility in organizational design is of even greater importance.

The term "system" implies that all parts of the organization are interrelated, so that the design of one necessarily affects the operation of another. In the context of sociotechnical systems, the open system perspective implies that the social and technological subsystems of organizations must be designed not only in relation to each other, but also with reference to present and future environmental demands.

Organizational Choice

Stated simply, the principle of organizational choice or *equifinality* suggests that there are many more ways to design organizations to achieve certain goals, and more than one means to an end. In this light, sociotechnical system theorists would have organizational designers consider the range of technologies available to perform some process, not just the latest or most sophisticated. In this way, the choice and operation of the technology can be adapted to the needs of organizational members for involvement in and control over the transformation process.

Beyond choices about which technology to employ, the concept of organizational choice implies that much of the design of an organization's operating system can be left to the people who directly interface with it; Herbst (1974) has referred to this aspect of sociotechnical design as "minimal critical specification." Generally, the behavior of members of sociotechnical systems should not be bound by rules, regulations, and procedures except when absolutely necessary; rather, rules should evolve over time as people learn more about the technology and each other. In this way, experimentation is encouraged and response to changes is enhanced.

Controlling Variances at Their Source

A variance, as the term is used in sociotechnical system literature, refers to any unprogrammed deviation from standards or procedures that is brought about by the state of materials used, or the normal state of technical procedures. Variances are referred to as key when they affect significantly the productivity of the organization or the quality of life of organizational members. By controlling variances nearer to their sources, disturbances in other parts of the system can be avoided, often saving large amounts of time, energy, and money.

In order to control variances nearer to their source, operators who conduct the processes in which they are created must be able to identify and correct variances when they occur. This requires that operators be given the *training, information*, and responsibility (*autonomy*) needed to detect and correct variances during their work. Frequently, this implies that operators be allowed to conduct their own *maintenance, quality control, supply,* and other ancillary functions, and that they be privileged to *information* concerning the operation of the system which might usually be reserved for management only.

Boundary Location

In all complex organizations, there is a need to break up the work of the total system into smaller, more readily coordinated and controlled tasks (Miller, 1959; Cherns, 1976; Rice, 1958; Cummings & Srivastva, 1977; Davis, 1979). Miller (1959) has suggested that boundaries are usually established on the basis of technology, territory, or time. Regardless of the method used for dividing up the work of the organization, there is always some difficulty created in terms of sharing knowledge and experience across boundaries. To the extent that boundaries interfere with the cooperative efforts of individuals or groups in accomplishing tasks, the performance of the organization will suffer (Pasmore, Srivastva, & Sherwood, 1978).

The problem of boundaries acting as barriers to communication among subsystems or between the organization and the environment is not eliminated by sociotechnical system design. However, to the extent that work groups can take responsibility for controlling variances that arise within their areas and control their own activities, supervisors can be freed up to concentrate on boundary control activities. Work groups which can control their own activities within the boundaries of their responsibility have been referred to as "autonomous" in the sociotechnical system literature (it should be noted that the term *autonomous work group* has taken on other connotations and implications as well, as will be revealed shortly).

Support Congruence

In every way possible, the system of rewarding, training, selecting, promoting, separating, and assessing employees should be consistent with the philosophy of sociotechnical work design (Cherns, 1976; Walton, 1972, 1978; Pasmore, 1978; Emery & Thorsrud, 1969; Hill, 1971; Thorsrud, 1977; Duckles, Duckles, & Maccoby, 1977; Davis, 1977, 1979; Margulies, 1968; Archer, 1975). This requires that management develop and make explicit its work design philosophy, and take actions consistent with that philosophy. For example, if the system is to function as a collection of interdependent autonomous work groups, individual rewards, externally imposed quality standards, and task-oriented management will interfere with the accomplishment of organizational goals.

In some efforts (Walton, 1972, 1978; Jenkins, 1978) designers have attempted to *eliminate all status differentials* between management and labor as a way of emphasizing the importance of consistency between stated philosophy and actions. More generally, this principle suggests that management should be aware of the implications of its design choices and be prepared to stand behind them in terms of formal organizational arrangements. (One way this can be done is to form an *action group* composed of employees from all levels of the organization to assist in sociotechnical analysis and redesign.)

Quality of Work Life Values

The drive for a higher quality of working life is reflected in sociotechnical system design through the creation of work which is challenging, encourages learning, provides variety, offers social support and recognition, allows the accomplishment of whole tasks, permits self-direction, and provides *feedback* concerning performance (Cherns, 1976; Trist, 1977, 1978; Davis & Trist, 1972, 1974; Davis, 1977; Walton, 1972, 1974; Emery, 1959, 1963; Cooper & Foster, 1971; Cummings & Srivastva, 1977; Pasmore, 1978; Osbaldeston, 1976; Pasmore & King, 1978; Thorsrud, 1972; Horner, 1976).

Given rising educational levels, demands for greater individualism, and alienation from traditional authority structures, it is becoming increasingly important to consider human needs in the design of work. Sociotechnical system theorists argue that the highest levels of productivity can only be achieved in an organization which integrates individual and organizational needs in the design of work itself. Emery (1963) suggests that this requires tasks which provide an optimal level of variety, a meaningful pattern of tasks, an optimum length of the work cycle, some scope for setting standards and suitable feedback of results, the inclusion of some auxiliary and preparatory tasks, the inclusion of tasks requiring skills worthy of respect, and a meaningful contribution to the utility of the product for the consumer.

Many creative work designs have been experimented with to achieve these objectives; probably the most commonly used is the autonomous work group. In efforts described by Walton (1972) and Poza and Markus (1980) for example, members of autonomous work groups rotate jobs, select their own members, decide on assignments, monitor their own performance, provide training for each other, and are paid for the number of tasks they know how to perform.

Continual Learning and Evolution

Because sociotechnically designed organizations are open systems, adaptable to changes in their environments, structural arrangements of people and technology will be in a continuous state of flux. To finalize a single design for joint optimization is to guarantee organizational obsolescence. Instead, organizational designers and members should constantly review and modify sociotechnical arrangements to better fit the ever-shifting demands of the environment (Walton, 1972; Cummings, 1976; Cherns, 1976; Miller & Rice, 1967).

Usually, a multilevel, multidisciplinary team is formed to evaluate the current system and propose alternatives to it. This group may be formed before a design is conceived in order to allow employee or union involvement in the creation of the sociotechnical system; in any event, this *action group* should continue to meet once the system is in operation to allow continual sensing and revision of the system as necessary.

A REVIEW OF SOCIOTECHNICAL EXPERIMENTS

The studies included in this review consist of those summarized by Taylor (1977), Friedlander and Brown (1974), Walton (1979), and Srivastva et al. (1975) plus a number of more recent efforts described in the literature.[3] This sample of studies is not completely exhaustive; many of

[3]The studies chosen from this review were gathered from a variety of sources. Journals in which the studies appeared include *Human Relations, Personnel, The Journal of Applied Behavioral Science, International Management, The Harvard Business Review, Organizational Dynamics, The Journal of Industrial Engineering,* and *The Academy of Management Journal.* Books providing reviews of studies analyzed here include L. Davis and A. Cherns, *The Quality of Working Life,* New York: Free Press, 1975; D. Jenkins, *Industrial Democracy in Europe,* Geneva: Business International SA, 1974; P. Hill, *Towards a New Philosophy of Management,* New York: Barnes and Noble, 1972; H. Andreatta and R. Bronwen, *Organization Development in Action,* Productivity Promotion Council of Australia, 1974. Two papers by J. Taylor, "Experiment in Work System Design: Economic and Human Results," *Personnel Review,* Vol. 6, No. 4, 1977 and "Quality of Work Life: An Annotated Bibliography," Los Angeles: University of California, Center for Quality of Working Life, 1972, cover the vast majority of studies considered here.

the studies occurred in North America in the seventies, and most took place in relatively small parts of organizations in existing facilities where there was greater opportunity for social than technical change. Furthermore, few of the reports of these studies followed their progress for more than two years, even though the issues of durability, institutionalization, and diffusion are critically important to the further development of the field. Obviously, this sample of studies does not do justice to the longer range, more pervasive studies that have been underway in Europe for some time, or studies conducted after 1980. Nevertheless, an examination of these studies does provide some interesting insights regarding the way in which sociotechnical system interventions have been practiced in the past. Altogether, 134 nonoverlapping efforts represent the focus of this review and analysis; a complete list of the efforts reviewed is available from the authors.

Several additional aspects of this sample of studies need to be pointed out before proceeding further. First, the studies vary greatly in both the degree to which they made use of the features above and in terms of the detail with which the efforts were described. The accounts provided by Walton (1972) and Poza and Markus (1980) are examples of relatively comprehensive efforts with good, complete descriptions; in other cases, details of the efforts undertaken and the results achieved are sketchy at best. In these latter cases, we were forced to make some interpretations regarding which features were and were not a part of the efforts; when in doubt, we did not include the study as an example of the use of the feature in question. Similarly, results were often not reported on a number of relevant dimensions; here again, we were forced to drop those cases from the analyses regarding the dependent variables under consideration.

We have elected to ignore differences related to the setting and populations involved in the efforts, since we are more interested in which features seem to produce consistently successful outcomes across settings. For like reasons, we have chosen to ignore when and by whom the interventions were undertaken, although such an analysis might produce interesting results. More important than all of the above, however, is the fact that these studies represent public accounts of sociotechnical system experimentation. We suspect that the number of attempts which have been undertaken but not made public is much larger than the 134 reviewed here; furthermore, because successes tend to be more widely published than failures, we would expect that the general experience with sociotechnical system designs is much less positive than will be reflected in this analysis. Even with these shortcomings, however, the present sample of cases will provide interesting insights into the features and effectiveness of the sociotechnical approach as applied over the last 30 years.

A review of the sociotechnical system experiments revealed that certain elements of sociotechnical system theory are applied more often than others; the following list of features is presented in descending order of use.

Percent of Studies Using This Feature	Feature
53	1. Use of autonomous work groups (involving both self-direction and interchange of tasks among members).
40	2. Emphasis on technical skill development.
22	3. Formation of an action group to recommend system changes.
21	4. Alterations to the reward system to make it consistent with sociotechnical system philosophy (for example, paying employees on a group basis).
16	5. Self-inspection of work quality by operators.
16	6. Technological changes to support desired social system.
16	7. Use of a team approach to work (in contrast to the autonomous work group approach above, this method involves the formation of teams which remain under direct supervision and in which members do not rotate jobs).
14	8. Facilitative leadership (involving explicit managerial training or selection activities aimed at improving problem solving and interpersonal skills).
12	9. Performance of maintenance by operators.
9	10. Minimal critical specification.
9	11. Feedback on performance (regular and direct).
9	12. Direct interface with customer or user by operator.
8	13. Self-supply of materials by operators.
7	14. Managerial information for operators.
6	15. Self-selection of peers by group members.
4	16. Status equalization between management and operators.
4	17. Pay for learning new tasks.
3	18. Peer review by group members.

Although this list is somewhat arbitrary and not exhaustive, we feel it is well suited to the review of sociotechnical system experiments which follows.

Table I presents the results of our review of the 134 sociotechnical system work restructuring experiments in terms of features employed and results attained.

Table I. The Use and Effectiveness of Commonly Discussed Features of Sociotechnical System Design in 134 Work Restructuring Experiments

Feature	Percent Of Studies Using This Feature (N = 134)	Productivity	Cost	Absenteeism	Turnover	Attitudes	Safety	Grievances	Quality
Autonomous Work Groups	53%	89%[a] / 58%[b]	85 / 53	86 / 72	81 / 76	100 / 53	100 / 71	0 / 0	100 / 58
Skill Development	40%	91 / 44	95 / 56	100 / 44	100 / 65	94 / 46	100 / 71	100 / 50	100 / 39
Action Group	22%	100 / 23	90 / 28	80 / 32	78 / 41	93 / 19	100 / 29	100 / 71	100 / 29
Reward System	21%	95 / 28	80 / 25	100 / 36	91 / 59	95 / 27	100 / 57	0 / 0	100 / 36
Self-Inspection	16%	90 / 13	90 / 28	89 / 28	86 / 35	100 / 21	80 / 57	50 / 13	92 / 36
Technological Change	16%	60 / 9	100 / 25	75 / 24	100 / 47	92 / 16	100 / 43	100 / 13	100 / 26
Team Approach	16%	80 / 17	80 / 13	75 / 12	100 / 18	100 / 21	0 / 0	100 / 13	100 / 13
Facilitative Leadership	14%	100 / 17	100 / 31	78 / 28	100 / 24	100 / 16	80 / 57	66 / 25	100 / 23
Operators Perform Maintenance	12%	88 / 10	88 / 22	100 / 20	83 / 29	100 / 13	100 / 29	0 / 0	100 / 19
Minimal Critical Specification	9%	100 / 10	100 / 25	100 / 16	100 / 29	100 / 13	100 / 29	100 / 25	100 / 19

Feedback on Performance	9%	100 / 10	100 / 25	100 / 12	100 / 12	100 / 13	100 / 14	100 / 13	100 / 10
Customer Interface	9%	100 / 6	100 / 6	75 / 12	67 / 12	100 / 10	0 / 0	100 / 13	100 / 10
Self-Supply	8%	80 / 6	80 / 13	100 / 12	67 / 12	100 / 10	100 / 29	0 / 0	100 / 19
Managerial Information For Operators	7%	67 / 6	83 / 16	100 / 16	100 / 18	100 / 9	100 / 29	0 / 0	100 / 13
Selection of Peers	6%	100 / 4	100 / 13	100 / 12	100 / 35	100 / 4	100 / 29	0 / 0	100 / 16
Status Equalization	4%	100 / 6	100 / 3	100 / 8	100 / 12	100 / 3	100 / 14	0 / 0	100 / 3
Pay For Learning	4%	100 / 6	100 / 13	100 / 16	75 / 18	100 / 16	100 / 29	0 / 0	100 / 10
Peer Review	3%	100 / 3	100 / 9	100 / 8	100 / 12	100 / 3	100 / 29	0 / 0	100 / 7
Percent of Studies Reporting on Variable		60	27	23	19	54	6	7	24
Percent of Those Successful		87	89	81	65	94	88	89	97

[a]The first percentage is the success ratio; i.e., number of successful attempts divided by number of total attempts using this feature and reporting results on this dimension (i.e., 89% of studies using autonomous work groups and reporting productivity data were successful).
[b]Second percentage is the hit ratio; i.e., number of successful attempts using this feature divided by total number of studies reporting success on this variable (i.e., 58% of studies reporting increased productivity involved autonomous work groups).

General Observations

A few general observations regarding Table I will be made before discussing the results in greater detail. The most commonly reported outcome dimensions in the work restructuring accounts were productivity (reported in 60% of the studies); cost savings (reported in 27% of the studies); absenteeism (reported in 23% of the studies); turnover (reported in 19% of the studies; attitudes (reported in 54% of the studies); safety (reported in 6% of the studies); grievances (reported in 7% of the studies); and quality control (reported in 24% of the studies). It should be noted that the measurement and reporting of results on these dimensions varied considerably from study to study; in some cases, detailed figures were provided, while in others statements such as "productivity increased" or "costs were reduced dramatically" were all that was available. Because of problems associated with comparing results on these dimensions even when data are available (Taylor, 1977), the figures shown in Table I are based on the percentage of cases indicating improvement on each dimension rather than on the *amount* of improvement reported. In this regard, it is worth noting that of the cases reporting productivity data, 87% reported productivity improvement as a result of sociotechnical system intervention. Similarly, the percentage of successful outcomes among studies reporting cost savings was 89%; the percentage for absenteeism is 81; for turnover, 65; for attitudes, 54; for safety, 88; for grievances, 89; and for quality control, 97.

The Use of Sociotechnical System Design Features

As indicated in the first column of Table I, the 18 sociotechnical system design features tended to be unevenly applied in the experiments reviewed. Autonomous work groups were utilized in the design of over half of the experiments; explicit attention to the development of technical skills of employees was a feature of 40% of the efforts. Technological changes were accomplished in only 16% of the studies, which is far less than one might expect given the espoused emphasis on joint optimization by sociotechnical system theorists. Minimal critical specification, feedback on performance, providing interaction with customers, allowing operators to supply themselves, providing managerial information to operators, allowing operators to select their peers, equalizing the status between employees and management, and rewarding employees for their knowledge were mentioned as features in less than 10% of the studies. Peer review, supportive of the maintenance of interpersonal relationships in autonomous groups, was utilized in only 3% of the efforts.

What do these figures indicate about the way in which sociotechnical system theory has been applied in organizations for the last 30 years? Our impression in reviewing the studies is that relatively few attempted to go beyond the use of autonomous groups and the focus on skill development to consider changes in related aspects of organizational structure and functioning. Because many of the experiments were conducted in small departments of larger organizations, it may have been difficult or impossible for the designers to arrange for changes in company policies, rules, and procedures for the sake of supporting the experimental changes. This is disturbing, given pressures for uniformity which over time have a tendency to undo much of what the sociotechnical system designer has accomplished (Pasmore, 1982; Walton, 1975). It is therefore quite possible that many of the experiments originally reported as successes have since ceased to operate as sociotechnically designed due to a failure to change the larger system of which the experimental unit was a part.

In a related vein, it is difficult to state how many of the features need to be employed before successful innovation is achieved. Relatively few of the interventions used all or most of the features simultaneously; yet the success rate overall is still quite favorable. Taking a leap beyond the data, it may be that doing whatever is necessary to alter the nature of the relationship between employees and the organization is more important than exactly *what* is done. Given that technological changes are reported in relatively few sociotechnical system experiments, we must conclude that much of the long-heralded sucess of sociotechnical interventions may have more to do with changes in the social system and in the qualifications of personnel than with the joint optimization of social *and* technical systems. At the same time, the efforts which were reported as most comprehensive in terms of the features were usually quite successful on the outcome dimensions; thus, it would seem that the *more* that is done to create the type of environment in which sociotechnical change can occur and be sustained, the better.

Keeping these observations in mind, and noting again that the features listed in Table I were often used in combination with one another, we shall now move to a closer examination of the relationships among the various features and outcome dimensions.

The Relationships of Features to Outcomes

In Table I, for each relationship between a sociotechnical system design feature and an outcome dimension, two percentage figures are reported. The first figure (which we call the "success ratio") refers to the percentage of efforts both employing the feature successfully and reporting results on the outcome in question. For example, 89% of the studies using autonomous work groups as a design feature and reporting productivity results were successful.

The second figure (which we call the "hit ratio") refers to the percentage of all studies reporting results on the outcome dimension which utilized the feature under consideration. Thus, for example, 58% of the studies reporting improved productivity used autonomous work groups in their design.

Several interesting observations can be made by examining the data in the rows and columns of Table I. Examining the columns first leads to the following statements concerning what it takes to impact the outcome dimension listed.

Beginning with an examination of productivity, we note that a full 58% (hit ratio) of the studies reporting increases in productivity utilized autonomous work groups in their design. Emphasis on skill improvement was a feature of 44% of the designs resulting in improved productivity, while the use of an action group and changes in the reward system were mentioned in over 20% of the successful efforts. All of the other features were used in less than 20% of the efforts resulting in improved productivity. We note specifically that technological change was a factor in only 9% of the cases for which improved productivity data were reported; furthermore, productivity increased in only 60% of the cases in which technological change took place. Clearly, the sociotechnical system design features which most often are used to improve organizational productivity are nontechnological in nature.

While many sociotechnical design features are not part of most studies which show increased productivity, *all* must be considered successful *when* they are employed. Technological changes are *least* successful, resulting in productivity improvement in 60% of the relevant studies. *No* unsuccessful applications of action groups, minimal critical specification, feedback on performance, customer interface, selection of peers, status equalization, pay for learning, and peer review were reported.

The same general trend observed in terms of productivity can be observed for most of the other outcome dimensions as well; the most used features are also most likely to be mentioned in reports of positive results on the outcome dimensions. Results in terms of increased safety and reduced grievances are reported too infrequently to draw conclusions regarding the comparative effectiveness of the various features on these dimensions.

Examining the data by rows yields additional surprises. Autonomous work groups, for example, are reported to have only positive effects on attitudes, safety, and quality, and figure in over 70% of the studies reporting improvements in absenteeism, turnover, and safety (hit ratios). In fact, studies reporting the use of autonomous work groups in design represent over *half* of those reporting positive results on *every* dimension (grievances were not measured in any study utilizing autonomous groups). Skill development, usually associated with autonomous work group design, is also highly impactful. Taken together, these results indicate that much of the success of sociotechnical system interventions to date can be attributed at least in part to the creation of social structures which allow people to learn task-related skills in an atmosphere of flexibility and self-direction.

Technological change, when employed, produces no negative results in terms of costs, turnover, safety, grievances, and quality, and few negative results in terms of attitudes and absenteeism. Reports of decreased turnover involved technological change 47% of the time (hit ratio), while success in improving productivity was the outcome dimension least likely to involve technological change (9%).

Interestingly, minimal critical specification, feedback on performance, selection of peers, status equalization, and peer review produced no negative effects on *any* dimension despite their infrequent use. Similarly, pay for learning, managerial information for operators, and customer interfacing produced completely positive results on all but a few dimensions. While these features might currently be regarded as "frills" by designers, it is obvious that they are underutilized given the positive results associated with their use.

Finally, we note that when features are reported at all, they are reported over 50% of the time in connection with positive results. We call again for the consistent reporting of all features which are part of both successful and unsuccessful efforts, not just those features which designers feel produce positive results.

IMPLICATIONS FOR RESEARCH AND ACTION

A number of issues stand out for us as needing attention by those interested in sociotechnical system approaches to organizational change. The first set of issues deals with methodological problems and problems associated with reporting results, while the second set of issues deals more broadly with areas needing additional research.

Methodological and Reporting Issues

It has been noted several times in this review that experimenters have tended to report on successful projects almost exclusively, leaving the literature almost void of data concerning the potential pitfalls of the sociotechnical approach. Moreover, even in reports of successful projects, those aspects of the design which are unsuccessful or abandoned are rarely mentioned. This selective reporting of design features could lead one to the conclusion that successful sociotechnical system change can result from the application of whichever design features one chooses, when in fact the best efforts seem to be those which are more systemic in focus.

Similarly, results on outcome dimensions tend to be selectively reported as well, either because results on unaffected dimensions were not measured or perhaps because the authors chose not to reveal where the outcomes fell short of their expectations. Obviously, more careful reporting of all features and all outcome dimensions of both successful and unsuccessful efforts would be desirable. Tichy and Nisberg (1976) have provided a framework which can be used to record the conditions surrounding a work restructuring effort; Table I of this review can be used as a guide to reporting both the features of an effort and associated outcomes.

Beyond reporting problems, certain methodological issues need to be faced squarely in future research undertakings; these include the problems associated with case study analysis, the use of varying analytical models and methods, and inconsistencies among instruments used for analyzing the organization and measuring the results.

As noted by Campbell and Stanley (1963), one-shot case study designs for research suffer from a number of threats to both internal and external validity. They arise from such things as the selection of the site, historical events which occur simultaneously with the intervention, and the loss and replacement of key personnel. More closely controlled experimental introductions of work restructuring are called for, with appropriate groups or organizations serving as controls during the experiments.

We noted that the use of different analytical models and methods would tend to lead to different diagnoses of the situation and hence to different recommendations for action. Much more attention needs to be paid to reporting the analytical methods used and how recommendations were derived so that experiments can be compared directly. In this way, more standard methods of analysis and recommendation generation can be developed which will reduce current difficulties with the comparability of efforts.

Finally, the diagnostic instruments and methods of measuring outcome dimensions vary widely from study to study. More uniform instruments and measurement devices should be developed so that the impact of various design features on outcomes can be more readily assessed across studies.

Research Issues

Research issues in the area of work restructuring concern both where and how design features are applied. Historically, sociotechnical system experiments have been undertaken primarily in blue-collar industrial settings, although white-collar experiments are beginning to be more common. Since many of the changes in workplaces in the future will be directly associated with changes in computer technology, the impact of the computer on work arrangements needs to be studied much more thoroughly than it has been. It is likely that new methods of analysis will be called for as the move into white-collar experimentation continues; these models will probably emphasize the relationship of the individual to the organization more than in traditional analyses, since the technology in white-collar populations is possessed by the members themselves and used at their discretion (Pasmore, Srivastva, & Sherwood, 1978).

Another research area beckoning the scientist is the study of the dynamics occurring within autonomous work groups; to date, only a handful of studies have looked into this most-often used feature of sociotechnical system design. Further inspection may reveal ways to increase the effectiveness of such groups and extend some of their benefits to other settings. The associated question of how to effectively manage a system composed of autonomous work groups is one that also deserves consideration. What types of training and behaviors are implied for first-line supervisors need to be more clearly identified; issues of integration of group activities across the organization through new forms of control systems need to be explored; the effects of personnel turnover need to be more closely investigated; and paths for promotion to and within the supervisory ranks in sociotechnical systems need to be clarified.

More broadly, sociotechnical innovation in large systems needs attention, given that most efforts to date have involved less than a few hundred people. Even though huge corporations have provided the sites for most sociotechnical experiments, only small parts of those organizations have actually been affected by sociotechnical change. Related to this issue is the need to study the diffusion process more fully and to develop methods for training large numbers of internal resources to implement sociotechnical changes.

Roadblocks to successful work restructuring need to be studied in order to develop strategies to overcome or avoid them. In many cases, the changes which have been successful have presented either extraordinarily good luck or unshakable top-level support in negotiating a sea of potential obstacles.

Finally, and perhaps most critically, we need to continue the study of how technology can be developed and designed to support the kinds of systems we are trying to create, both in industrial and service environments. Since relatively few of the experiments which have been conducted have actually involved technological changes intended to support the systems, and since success in doing so has been more limited than we would expect, it is obvious that we have much more to learn in this regard. More cooperation needs to take place between the industrial engineer and the social scientist; to ensure that this happens, there needs to be more appreciation of the work of each by the other. Further, the study of the processes of technology innovation and transfer holds great potential for producing results that will shape the way organizations and the people within them behave in the future.

CONCLUSIONS

We have reviewed the literature on sociotechnical theory and experimentation and have found some important discrepancies. Most of these discrepancies relate to the unsystematic use of espoused sociotechnical design features, and the relationship of design features to results reported. Although studies tend to be reported selectively, we were able to conclude that certain design features, such as autonomous groups and increasing skills of members, were frequently employed while others, including technological change, were not. Some of the features, such as minimal critical specification, the provision of feedback, pay for learning, status equalization, and peer review seem to be underutilized given the results they produce. Problems and frontiers facing scientists conducting research in the future were explored.

Of the many learnings obtained from this review, probably the most important is the need to pay closer attention to the development of technology and to better understand its impacts on behavior. It is difficult to separate many of what are currently cited as work restructuring efforts from human processual approaches to organizational change. Because the largest increases in organizational productivity are brought about by technological developments, intervening in the human processes of organizations has limited potential for shaping organizations in the long run. Profit- and cost-conscious managers will continue (correctly) to opt for technologies which allow them to stay even with or ahead of the competition. The challenge for the social scientist lies in helping to create the technologies of the future, not in correcting the problems created by the already outdated technologies in use in most organizations. Sociotechnical systems theory provides the potential vehicle for meeting the challenge; but as currently practiced and researched, the potential has barely been tapped.

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