

Sociotechnical Systems in Health Care: A Field Experiment

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This article describes an intervention that employed sociotechnical systems (STS) analysis in the laboratory of a major health care institution in the Midwest. The analysis was performed on two departments of the laboratory to determine opportunities for improving effectiveness, facilitating the introduction of new technology, and enhancing the work experience of technologists. The authors measured the results of the intervention by conducting a survey of technologists before and after the change effort and through follow-up interviews with a sample of physicians, supervisors, and technologists. The intervention did not achieve the results intended, and the authors present their explanations for why this occurred and suggest implications and recommendations for future STS applications to health care settings.

The politics of power and the systemic complexity of health care organizations have limited sociotechnical systems (STS) experimentation in the health care setting. Moreover, the few experiments undertaken have either been underreported or misconstrued. Experiments by Stoelwinder and Clayton (1978) and by Glor and Barko (1982) have produced encour-

aging results, but have been limited in scope and generalizability. Clearly, more experimentation is needed to help us understand the full potential of STS applications to health care and to learn more about the dynamics surrounding such implementation. With this article, we seek

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to add to the knowledge of STS experimentation in health care.

THE INTERVENTION AND STUDY

Our study and intervention focused on a health care clinic founded in the 1940s by a small group of physicians who believed that medicine was becoming too complex for any sole practitioner to practice effectively. Since that time, the clinic's group practice has grown to include more than 400 physicians emphasizing excellence in patient care, education, and research. Its members consider the organization's stature to be the product of a blend of specialized medicine, advanced technology, physician management, and high regard for the 7,000 employees supporting the clinic's mission.

Leaders of the clinic's division of human resources and division of laboratory medicine realized that the introduction of new technology to the clinic's laboratory would require that employees learn new skills. The leaders further recognized that the introduction of new technology would alter existing working arrangements, affect relations between physicians and employees, and provide opportunities for redesigning the organization. Following a preliminary discussion with the clinic's organization development (OD) staff, the laboratory chairman agreed that his division should be studied more closely to determine opportunities for improving effectiveness, facilitating the introduction of new technology, and enhancing the work experience of technologists. He further agreed that the OD staff's study would focus on the departments of biochemistry and microbiology, as these two departments represented the extremes of a continuum of technological advancement, with biochemistry being the most advanced and microbiology the least advanced.

The human resources department had just completed a division-wide job analysis identifying the work performed by medical technologists. Although the technologists found the analysis's descriptions accurate, these employees—particularly those in biochemistry—considered their current duties inappropriate. Indeed, many complained that their skills were underused, that communications within the laboratories were insufficient, that work was distributed unevenly, and that the medical staff did not pay them the respect they deserved. The laboratory chairman admitted to having concerns about the effects of specialization on the technologists' jobs, and the analysis noted that automated methods were continuing to encroach upon the roles of medical technologists, simplifying the work to the point that many had come to believe that technically trained high school students could perform it. These complaints are consistent with the findings of Hajek and Blumberg (1982), whose research found that a lack of challenge was the primary cause of job turnover among medical technologists.

The intervention began in 1982 with a series of meetings—attended by laboratory medical staff and employees—intended to describe the STS methodology to be used, recruit volunteers to assist in the analysis, and test the support of those in the laboratory for the process. At these meetings, the project was described as a method for appreciating the work and personnel of the two departments under study and for identifying problems and opportunities to which the clinic could respond. The meetings ran smoothly, and those attending asked only a few questions regarding specific aspects of the intervention.

After several meetings with the representative groups, the OD staff began their analysis. The Job Diagnostic Survey

(Hackman & Oldham, 1980) was administered to all technologists in the biochemistry and microbiology departments, and individual interviews were conducted with a random sample of one-third of all technologists from each laboratory. The entire process of data collection, analysis, and report preparation took about two months.

For the next four months, the representative groups met weekly to review the findings of the analysis and to prepare recommendations for change. At the end of this period the groups compiled a report on the steps that had been taken to change the laboratory's organization. These changes addressed some of the issues raised in the analysis, but they fell short of constituting a true STS redesign of the work in the laboratory. Instead, most of the changes built on improvement efforts that had been underway prior to the analysis and on actions taken by the new biochemistry director upon his arrival. For example, in considering the issues associated with unclear roles in the medical/administrative hierarchy of the laboratory, the representative groups simply affirmed the existing organizational structure, although they did note that the leaders of the laboratory should identify and clarify objectives more precisely. In another instance, efforts to solve technical problems were set aside until a new computer system—designed to correct some of the problems of lost or untimely information—could be installed. In a third case, employees had suggested that informal problem-solving groups be formed to allow more rapid identification of problems and more direct employee participation in solving them, but when the representative groups perceived pressure from the laboratory leaders they ceased promoting this suggestion and instead asserted that employees could best participate in problem solving on a day-

to-day basis by sharing their ideas with their supervisors.

Several significant changes did occur, however. A dual career path was established to allow technologists some degree of upward mobility other than through moving into administrative positions. Two subsections of the biochemistry laboratory were combined, with ensuing job rotation by members of one section with those in the other. New equipment was ordered to replace some of that which had become outdated, and the biochemistry laboratory underwent extensive changes in its physical environment to make work there more pleasant. Eventually, the new computer system was put into operation, and this reduced the volume of paperwork necessary.

Two years after these and other changes were introduced, members of the laboratory were asked to reflect on the impact the study had on their work. They were also asked to comment as to why they thought some changes had been enacted whereas others had not.

RESULTS OF THE INTERVENTION

Quantitative results

Table 1 indicates that survey data gathered using the Job Diagnostic Survey before and after the intervention show that the intervention had mixed results for the biochemistry and microbiology laboratories. Scores for medical technologists in biochemistry declined on 15 of the 16 measures, with motivating potential scores (MPS) dropping from an average of 109 to one of 67 ($p < .01$). This decline in MPS was clearly the opposite of the intended results for the intervention.

For the medical technologists in microbiology, small declines on 10 of the 16 measures were observed, with the only

Table 1
Pre- and Postintervention Comparisons of Job Diagnostic Survey Scores
for Medical Technologists

<i>Variable</i>	<i>Biochemistry</i>			<i>Microbiology</i>		
	<i>Time 1</i>	<i>Time 2</i>	<i>p*</i>	<i>Time 1</i>	<i>Time 2</i>	<i>p</i>
Skill variety	3.8 (1.4)**	4.4 (1.2)	n.s.	4.5 (1.2)	4.1 (1.4)	n.s.
Task identity	5.5 (1.2)	4.7 (1.2)	<.01	5.0 (1.6)	4.9 (1.2)	n.s.
Task significance	5.9 (1.3)	5.5 (1.5)	n.s.	5.9 (0.9)	5.5 (1.3)	n.s.
Autonomy	4.2 (1.5)	3.4 (1.1)	<.05	3.9 (1.5)	3.8 (1.3)	n.s.
Feedback—job	4.7 (1.3)	3.8 (1.3)	<.01	4.4 (1.3)	4.6 (1.3)	n.s.
Feedback—agents	3.6 (1.4)	3.0 (1.0)	n.s.	3.4 (1.8)	3.2 (1.7)	n.s.
Dealing with others	4.3 (1.3)	5.0 (1.0)	<.05	4.4 (1.2)	4.4 (1.3)	n.s.
General satisfaction	4.1 (1.6)	3.3 (1.2)	<.05	4.6 (1.6)	4.4 (1.7)	n.s.
Internal motivation	5.5 (1.0)	5.3 (0.9)	n.s.	5.6 (1.0)	5.7 (1.0)	n.s.
Satisfaction with pay	5.2 (1.2)	4.8 (1.4)	n.s.	5.2 (1.5)	5.1 (1.3)	n.s.
Satisfaction with job security	5.5 (1.0)	3.8 (1.7)	<.01	5.7 (1.1)	3.8 (1.8)	<.01
Satisfaction with social relations	4.5 (1.1)	4.3 (1.1)	n.s.	4.7 (1.1)	4.8 (1.9)	n.s.
Satisfaction with supervision	4.5 (1.7)	2.7 (1.4)	<.01	4.5 (1.5)	4.3 (1.9)	n.s.
Satisfaction with growth opportunities	3.6 (1.4)	3.1 (1.2)	n.s.	3.8 (1.5)	4.0 (1.5)	n.s.
Growth need strength	6.1 (0.9)	6.0 (0.9)	n.s.	6.0 (0.8)	5.7 (0.9)	n.s.
Motivating potential***	109 (64)	67 (32)	<.01	94 (61)	92 (56)	n.s.

**p* = significance of difference between means, two-tailed t-test; n.s. = not significant.

**Likert scales, 1 = low, 7 = high. First number is mean, number in parenthesis is standard deviation.

***Motivating potential score: 1 = low, 343 = maximum (Hackman & Oldham, 1980).

significant decline taking place in the category of satisfaction with job security. The average MPS declined slightly from 94 to 92. In both departments, the decline in the measure of satisfaction with job security undoubtedly reflects employee concerns for both the continued automation of work in the laboratories and the constant pressure to reduce laboratory costs.

With almost three years taking place between administrations of the survey, it is difficult to determine the extent to which the differences in the scores reflect the effects of the intervention rather than other events that occurred during that period. In any event, the results clearly indi-

cate that the intervention did not have an especially positive long-term impact.

Interview results

To understand the quantitative data more fully and to discern the employees' reactions to the STS process, researchers conducted interviews in 1985 with a sample of physicians, supervisors, and technologists who had been involved in the intervention in each department. In general, the responses indicate that personnel felt that, whereas some problems had been addressed, many important ones had not, and most of the respondents were disappointed with the outcomes of the intervention.

Biochemistry department

The interviews with personnel in the biochemistry department elicited responses reflecting the significant negative changes in the Job Diagnostic Survey scores (see Table 1). Before reporting further, we will elaborate on the context of the intervention.

Most persons interviewed attributed the declines reflected in the Job Diagnostic Survey results not to the STS process, but rather to the new leaders' responses to the suggestions made for change in 1982. At that time, the department faced intense pressure to reduce costs, and employees were worried that the clinic might turn to outside, commercial laboratories as a more efficient source of testing services. All of the personnel looked forward to the arrival of the new director and held great expectations that improved laboratory management would better meet the needs of both the social and technical system. Indeed, upon arrival the new director did take action in response to issues raised during the intervention. The physical environment became more spacious and less chaotic, problems with lighting and noise were reduced, and areas for breaks and conferences were improved. Furthermore, employees noted that clear roles and expectations had been developed for the laboratory and that policies were applied more consistently. A formal communication structure had been established, and a technical career path—in addition to the traditional supervisory career path—had been implemented. The employees interviewed agreed that new automated systems for conducting tests and communicating results to the users of the laboratory's services had contributed greatly toward improving the department's support for patient care.

Despite this situation, before we conducted the interviews we were warned that we would have difficulty getting anyone

to speak about the STS intervention, that employee morale was at its lowest, and that many perceived the STS process as ammunition for management to use in eliminating malcontents (even though none of the intervention's data identified individuals who expressed complaints). Physicians and supervisors viewed the technologists as increasingly less appreciative of their efforts, felt they lacked a professional, systemic approach to laboratory medicine, and considered them inappropriately driven by narrow self-interests related to job security.

The interviews indicated that the technologists had come to view the staff as uncaring, inhumane, deceitful—as “the enemy”—and felt that the staff expressed humanistic values it failed to act upon. The staff and supervisors admitted that urgent needs for immediate changes had caused them to eschew more participative methods of problem solving as too time consuming, and the technologists felt the resulting changes were narrowly directed and designed to eliminate the autonomy they had expected and had experienced under the previous management—which the technologists themselves described as overly laissez faire. Moreover, the introduction of ever more highly automated analytic equipment, robotics, and bureaucratic management structures conflicted with the technologists' perceptions of themselves as autonomous professionals capable of making important decisions affecting patient care, causing them to feel like mere laborers who had lost control of their identities and could easily be replaced with “spare parts.” These changes in management and technology eliminated much of the interpretive diagnostic support role the technologists had traditionally enjoyed. The technologists attributed these changes to the new leadership and viewed the STS intervention as a tool the leaders used to impose their solu-

tions to problems affecting the laboratory on those who had provided the data identifying these problems.

Microbiology department

In the microbiology department, follow-up interviews with members of the staff, the representative group, and two problem-solving groups indicated that those in the department believed the intervention had no dramatic, tangible results. Although the STS effort in that department was viewed as an experiment taking place in a basically healthy system that did not require as much change as the biochemistry department, the intervention created high expectations. Many of the technologists and technicians felt disappointed because the issues identified during the analysis—such as unclear and conflicting management roles and a lack of recognition for work performed—were not resolved by the intervention, and they expressed apathy and skepticism about the project.

Some modest changes did occur that can be attributed to the data collection and feedback components of the intervention, which exposed some simple problems that were easily solved by management and made persons more aware of the departmental issues. The intervention also led supervisors to become more aware of the need to solicit employee participation in problem solving, and as a result more persons reported an increase in their level of overall participation.

The technologists' skepticism was fueled, however, by the perception that their ideas were sought but not taken seriously. Over time, they ceased identifying problems or offering solutions, and this led supervisors to become frustrated. In general, personnel reported feeling an "us-vs.-them" mood.

Those interviewed did note that a positive effect of the change was continued group activity toward solving specific

problems, such as redesign of the accession area's space, revision of procedure manuals, and design and implementation of a new telephone system. Those participating in the representative group or in either of the task forces evolving from it felt more closely identified with the department as a whole, a heightened sense of appreciation for the value and difficulty of administrative work, and more capable of solving problems and working in groups.

From the interviews, the researchers learned of several barriers to further change. These included the following.

- The representative groups and problem-solving groups were not sufficiently integrated into the department's management structure. Because of this, the groups had only minimal control, suffered from false starts, and spent too much time selecting tasks and deciding how to make decisions.
- The original data gathered were framed in departmental terms and perceived as too open ended and distant from the work at hand, whereas concrete, sectional issues would have been perceived as more relevant and tangible. Problem-solving groups found broad behavioral issues such as role relationships difficult to analyze and manage.
- Those who did not participate in the representative and problem-solving groups felt uninformed about the groups' activities and resented assuming some of the participants' work during the group's meetings.
- The representative group lacked a clear, ongoing sense of purpose.
- Because the problem-solving groups thought they were to function autonomously and unassisted, and management perceived its role as that of allowing the groups freedom, the

groups did not seek help and management did not offer all the resources it could have provided.

CONCLUSION AND DISCUSSION

Overall, the intervention apparently did not achieve the results intended for either laboratory—that is, it did not lead to a new, highly effective work system whose members felt they were contributing to their full potential toward the success of the operation. The STS process used seemingly failed to overcome traditional relationships or procedures so that opportunities for participative redesign of work could be introduced.

Lacking a more rigorous research design that included control groups, determining the exact causes of the effects noted in this article is difficult. From our

observations and data, however, we have developed several alternative explanations for the results of the intervention, and these have important implications for STS practitioners.

Theory failure

When a behavioral science intervention produces unexpected results, the first place to look for clues as to why this happened is the underlying theory (Weiss, 1972). Perhaps the theory is defective, and the presumed relationship between the independent and dependent variables does not in fact exist or is moderated by other variables not considered. With respect to the study addressed in this article, one could ask whether sociotechnical systems theory—developed in industrial settings—is appropriate for health care settings.

Table 2
Pre- and Postintervention Comparisons of Job Diagnostic Survey Scores for Self-Directing Microbiology Technicians

<i>Variable</i>	<i>Time 1</i> <i>N</i> = 8	<i>Time 2</i> <i>N</i> = 9	<i>p*</i>
Skill variety	3.8 (1.7)**	4.2 (0.9)	n.s.
Task identity	2.6 (1.6)	3.7 (1.3)	n.s.
Task significance	6.2 (0.8)	5.8 (1.2)	n.s.
Autonomy	2.9 (0.9)	4.1 (1.0)	<.05
Feedback—job	3.5 (1.3)	4.6 (1.2)	n.s.
Feedback—agents	2.3 (1.4)	4.8 (1.9)	<.01
Dealing with others	5.8 (1.5)	5.8 (0.8)	n.s.
General satisfaction	5.1 (1.1)	5.8 (0.8)	n.s.
Internal motivation	5.8 (0.4)	5.9 (0.9)	n.s.
Satisfaction with pay	4.6 (1.4)	5.2 (1.5)	n.s.
Satisfaction with job security	6.3 (0.5)	5.7 (1.1)	n.s.
Satisfaction with social relationships	4.3 (1.2)	5.7 (1.3)	<.05
Satisfaction with supervision	3.2 (1.6)	5.6 (1.6)	<.01
Satisfaction with growth opportunities	3.4 (1.1)	5.0 (0.9)	<.01
Growth need strength	6.1 (0.7)	6.1 (0.9)	n.s.
Motivating potential***	47 (35)	93 (51)	<.05

**p* = significance of difference between means, two-tailed *t*-test; n.s. = not significant.

**Likert Scales, 1 = low, 7 = high; first number is mean, number in parenthesis is standard deviation.

***Motivating Potential Score: 1 = low, 343 = maximum; (Hackman & Oldham, 1980).

We believe that STS theory is indeed appropriate in this setting. Perhaps the most convincing support for this conclusion comes from two examples of joint optimization within the laboratories. In the first case, when the supervisor of the accession area took maternity leave, the remaining technicians began to function as an autonomous work group, using self-regulation, increased contact with their customers—that is, staff and those in other sections of the laboratory—and group problem-solving techniques to control internal and external variances. Not surprisingly, this caused these technicians' MPS scores to increase significantly ($p < .05$) (see Table 2).

In the second case, we discovered that the technologists working on the third shift (11 p.m.-7 a.m.) also performed in ways consistent with STS design principles. As generally occurs with third-shift work, this situation posed fewer structural barriers to workers' interdependence and to their direct contact with clients. The technologists had the opportunity to complete greater portions of tasks themselves, with more autonomy, and to use a wider variety of skills, track individual patients' progress—thereby getting more direct feedback on the results of their efforts—and develop relationships with nurses and attending physicians. Management reports that the third shift shows the highest levels of productivity and that these technologists are eager to learn and complain only when they do not have enough work to do.

If one accepts the finding that STS can work in health care settings, one must look elsewhere to explain why this study produced the outcomes it did.

Method failure

If one has determined that the theory is not faulty, the next source of an unex-

pected outcome of an experiment that should be considered is the method used. Were the variables manipulated improperly, or were the wrong variables manipulated? More simply, a method failure indicates that one did not do what was required, or else did it poorly.

With the advantage of hindsight, we can see how we would have conducted the intervention differently. For one, we would have attempted to link the clinic leaders' values of experimentation with the employees' felt need for change. In health care, the commitment of physicians is crucial for success, but we failed to get representatives of the laboratories' external environment directly involved in the analysis and changes made. Had patients, nurses, and—most important—hospital and clinical physicians participated in identifying the types and levels of services they expected from the laboratories, more pressure for change may have been exerted. As conducted, the project was viewed as something "nice" to do, as possibly meeting the special interests of the technologists, but not as vital to the needs of the patients and outside physicians.

We also would have spent more time in the beginning of the intervention educating both management and the employees. The experiment depended too much on our direction because no one else fully understood the process of change or the possibilities we envisioned, and this made it difficult for management to provide consistent leadership or for employees to assume meaningful roles with respect to the process. Later, when recommendations for change were made, we saw that our expectations did not match those of the system's members. We had not adequately prepared them to understand or accept our ideas. Even worse, we had failed to make these persons capable of generating their own ideas.

After educating personnel, we should have worked harder to ensure that the analysis of the technical system was followed up completely. This follow-up was further complicated by the practice of aggregating and feeding back the data at the overall laboratory level, rather than at the sectional level, which would have allowed for more meaningful inquiry. Although the laboratories were moving slowly toward greater automation, the technology was still primarily knowledge-based and focused on work that could be carried out by a single technologist performing a discrete set of procedures. Imagining new ways to do the work came no easier to the client than to the consultants; attention tended to drift toward the social system analysis, which was more familiar to most persons and therefore easier to understand. As a result, many of the changes were aimed at making persons happy rather than at redesigning the way work was performed.

Cultural factors

We realized from the start of the project that the specialization and class structure of the health care environment posed unusual challenges to an STS intervention. Nevertheless, the clinic's leaders assured us that physician support for the intervention would be forthcoming. Several factors, including the clinic's reputation for innovation, led us to accept without question the client's statement of support for change. We subsequently learned, however, the contradictions and barriers a culture can present to STS redesign.

We soon discovered that the possibility of increasing collaboration throughout the system was less than anticipated because of the members' assumptions about authority and the delegation or release of power. In most industries, delegating authority is normative, and decisions about

releasing power are left to the discretion of individual managers. In health care settings, however, authority is culturally determined, demarcated by educational requirements and professional codes, and supported by legal and regulatory realities. The issue of physicians' delegating authority to nonphysicians—or collaborating with them in setting policy—is simply unlikely to arise. The authority of the physician is not questioned. Although we recognized that this situation exists in most health care systems, we thought that this system would be an exception. We did not question this judgment until recommendations for change were made.

This view of authority not only resulted in cultural resistance to the fundamental premise of collaboration that underlies STS analysis. Assumptions about physician responsibility and authority also fueled resistance to the following two principles of STS design: that one should control external variances at the lowest possible level, in this case by involving the technologists in educating their customers (the hospital and clinic staff); and that one should enhance the design of the work through contact and feedback, which would cause the technologists to interact with customers, patients, and physicians. The staff felt that they alone should interact with the physicians, and presumed their colleagues shared this view.

Specialization also posed a surprisingly potent barrier to work redesign. Whereas multiskilled teams could have been created to manage the work of several sections of the laboratory, those who we felt had the most to gain from such a change—the technologists—resisted it the most. We thus discovered that members of the health care culture associate specialization with occupational status. The technologists eschewed cross-training and autonomous work groups because they feared losing their marginal respect within the system.

Within a health care environment, the intervenor thus finds the following two STS principles contradictory: that one should design a system compatible with the organization's culture, which in this case was characterized by specialization and assumptions proscribing the release of power by physicians; and that one should design a system compatible with concepts of egalitarianism, multifunctionalism, group work, contact with customers, and control of external variances at the lowest possible level.

To address this contradiction, future STS experiments must follow one or both of two approaches. The first demands that the intervenor seek to change the culture before attempting to provide a shift from traditional to innovative work arrangements. For such an effort to succeed, a system's members must be capable of simultaneously existing in their culture and being objective about its strengths and weaknesses. A "catch 22" exists, however: Such a cultural change requires effective participation, which itself depends upon change in a culture that does not value and permit participation except for those in dominant positions. Further research should address this dilemma.

The second approach calls for one to accept the contradiction—that is, to find ways of bringing about social and technical innovation while also maintaining cultural continuity. To follow this approach, one must appreciate the culture and look for opportunities to develop the system's potential for STS change; strategies for doing this appear later in this article.

Learning failure

Although method failure and cultural factors may largely explain the results of this intervention, we also believe that a "learning failure" occurred between the consultants and client that hindered our

collective ability to critically examine cultural assumptions and social/technical arrangements. From the start, we mistakenly assumed that the clinic leaders' willingness to undertake the analysis meant they felt committed to exploring new ideas and experimenting with work redesign. More important, we were unable to perform "co-inquiry" with the leaders. Both parties operated according to different theories of organization. For example, our theory devalues overspecialization in a work design, whereas theirs accords specialization a central role. As a result, we advocated a theory the client would only consider alien and unsuitable. Our attempts to confront the leaders may not have had maximum success because we viewed the client from the perspective of our theory and failed to consider the leaders' vantage point. While we sought to stimulate their acceptance of our theory (a second-order change), they sought to make incremental changes within their own theory (a first-order change). The cultural model of diagnosis and prescription of experts, which they expected and to which we succumbed, structures inquiry in a manner that allows only first- and second-order learning to occur.

The consultants and leaders lacked the capacity for recognizing each other's theories and inquiring collectively as to the most appropriate means of addressing the situation. Fry and Pasmore (1983) describe this capacity as **frame-breaking**, as opposed to single-frame or multiple-frame interaction. In frame-breaking interactions, both parties to a relationship must be prepared to set aside their traditional views—or frames—so that they may develop a new, shared perspective. To do this, they must form a learning partnership and be capable of both appreciating and challenging the other's views so that they may look past existing frames and see new possibilities.

New directions

We learned a great deal from this experiment to support the application of sociotechnical theory and methods of redesign to a health care setting. To enhance the prospects for the success of such experiments, we make the following recommendations.

1. Develop a capacity for envisioning technical systems possibilities. Those conducting STS interventions in health care settings face difficulties envisioning new possibilities for technical system design. The esoteric knowledge that constitutes the technology of health care is not easily assimilated by applied behavioral scientists. Furthermore, cultural norms favoring specialization inhibit those within the system from exploring new possibilities for organizing the technical aspects of work. To go beyond existing frames of reference for viewing the technical system, an intervenor may expand the consulting team to include one or more experts in the technology. Educating these experts in STS theory may stimulate their thinking and encourage them to imagine new ways of organizing technical arrangements. Another approach calls for bringing in external experts from existing innovative health care organizations: These experts can review the system and possibly provide alternative technical models based on their own experiences. In addition to helping organization members consider new perspectives, an external consultant may also help those in the system envision what technical changes will likely occur within the next three to ten years and how this will affect the system.

2. Discover and nurture sources of innovation existing within the system. In reevaluating the project, we realized that two sources of innovation thrived within the clinic: the accession area technicians' autonomous work group and the technologists working on the third shift. Had

these "islands" of innovation been identified during the early phase of data collection, we could have used them as a source of dialogue and co-inquiry, which would have provided a stimulus for third-order change. The existence of these alternative models of sociotechnical arrangements means that they were not countercultural. The clinic's leaders, however, were not conscious of these innovative arrangements as alternative models. By making the leaders aware of such sources of innovation and their effectiveness for the situation, consultants can help an organization expand its range of alternatives by building upon and learning through its own strengths. For this strategy to succeed, the consultants must be able to engage in an appropriate learning process with the clients. Such a strategy emphasizes the search not only for variances, but also for innovation and diversity.

Health care delivery systems face increasing environmental pressures to increase their effectiveness. This should make continued experimentation with STS redesign even more important. The more we learn from our successes and failures, the faster diffusion will occur.

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