North American Design of Nonroutine Work Systems (1980s–1990s)
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Introduction

The North American approach to nonroutine work design is set in the context of the 1980s, during which time the developed world was undergoing a major structural transformation from industrial to postindustrial society. Daniel Bell (1973) argued that postindustrial society would be information-led and service-oriented and that it would replace the industrial society as the dominant system. He further argued that postindustrialism would entail a shift from manufacturing to services and the centrality of new-science or information-based industries.

The salient characteristics of the preindustrial, industrial, and postindustrial eras such as key economic activities, strategic resources, core technologies, critical skills, and the primary modes of work, are summarized in table 1. As table 1 shows, the nature of work in postindustrial society shifts from a reliance on fabrication activities, financial capital, machine technology, and the division of labor to information activities, human capital, knowledge processes, intellectual technologies, human interaction, and networked labor.

Table 4.1. Emergence of Post-Industrial Society (Adapted from Daniel Bell, 1973)

Major Eras, Key Economic Activities	Strategic Resources	Core Technology, Critical Skills	Primary Modes of Work	Methods and methodology
Pre-Industrial era Extraction activities such as agriculture, mining, fishing, timber, oil and gas	**Raw materials** converted to outputs by the natural power of wind, water, draft animals and human muscle	**Craft technology;** Artisans, manual laborers and farmers	Physical labor	Common sense, trial-and-error, and experience
Industrial era Fabrication activities such as goods production, manufactured durables and non-durables, heavy construction	**Financial capital** converted to outputs using manufactured energies-- steam, electricity, coal, oil, gas and nuclear power	**Machine technology;** Industrial engineers, semi-skilled and skilled workers	Division of labor	Empiricism and experimentation
Post-Industrial Era Processing and information activities • Transportation and utilities • Trade, finance, insurance, real estate • Health, education, research, government, recreation, entertainment	**Human capital** converted into outputs via information, knowledge processes, programming, algorithms, computers, exchange, data transmission and human interaction	**Intellectual technologies;** Scientists, technologists, professionals, and other highly skilled workers	**Networked labor**	Models, simulations, decision theory and systems thinking

Virtually all of what Bell (1973) predicted has been realized, and probably more profoundly than anyone could have imagined forty years ago. We have witnessed the rapid deindustrialization and offshoring of manufacturing in North America and much of the developed world and a dramatic, although bifurcated shift to well-compensated “gold-collar” work in information and knowledge-intensive workplaces and to poverty-level “iron-collar” work and wages in the bourgeoning service industry.

The new tools of this era were word processors, integrated voice/data switches, portable computers, and fax machines. By the 1980s and 1990s, work increasingly involved processing data and information and translating it into knowledge rather than transforming raw materials into tangible products. The primary task of knowledge work is nonroutine problem solving that requires a combination of convergent, divergent, and creative thinking (Reinhardt, Schmidt, Sloep, and Drachsler 2011). Knowledge work is typically nonrepeated, unpredictable, and emergent and primarily involves the management of unstructured or semistructured problems (Keen and Morton 1978) characterized by imprecise information inputs, varying degrees of detail, extended or unfixed time horizons, dispersed information formats, and diffuse or general scope.

The practice of sociotechnical systems design from the 1950s through the 1970s reflected the predominant workplaces of that era, process and manufacturing industries, and work processes that tended to be fairly routine and consistent. But by the end of the 1970s, the structural transformation from an industrial society to a postindustrial society was accelerating, along with the fundamental nature of work and the workplace. Given the success of SocioTechnical System design initiatives in process-industry and manufacturing settings, attention moved to office and administrative settings to provide a more comprehensive approach to organization design.

Tom Cummings (1978) suggested that STS’s shop-floor heritage and its language, concepts, and orientation limited its application in office settings.[1] He also claimed that the relatively lower reliance on technology in the office—at least, at that point in history—created an imbalance between the social and technical systems and rendered the analytic tools less useful.

Eric Trist (1984) and Cal Pava (1986) echoed these concerns when they argued that conceptually, STS design had fallen into a rut and that overreliance on customary practices such as the nine-step method had stifled innovation and restricted STS’s applicability to the emergent workplace.

The North American approach to nonroutine work-system design was formally introduced in 1983 with the publication of Pava’s seminal book, *Managing New Office Technology: An Organizational Strategy*.

In this chapter, we explore the broader context and the changing nature of work and work systems that prompted Pava’s approach to designing nonroutine work. We discuss the STS principles that served as the foundation of his approach and provide an overview of nonroutine work design. Virtually all of what Bell (1973) predicted has been realized, and probably more

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[1] It should be noted that Pava commented that Cummings’s critique of STS in office settings was not fully correct for routine or even semiroutine office or clerical work. According to Painter (2015), STS analysis and design had been used very effectively, though not often, in settings such as an office automation project with airline-ticket processing and public-service redesign in Ontario.

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In subsequent articles, Pava (1985, 1986) recognized that the distinctions between blue-collar and white-collar work was decreasing due to increased reliance on knowledge work in both the office and the factory, especially given the emergence of “smart” equipment, advanced manufacturing, artificial intelligence, and the emerging integration of computer and communications technology. He argued forcefully that to be relevant and valuable in the 1990s and beyond, STS design concepts and methods themselves needed to be redesigned. We conclude this chapter with a discussion of the impact of Pava’s thinking on the current theory and practice of STS.

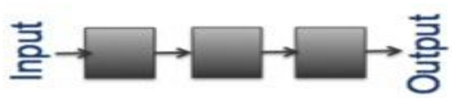
In assessing this emerging organizational landscape, Pava recognized two key shifts in the nature of work that would require “an overhaul in STS design: the shift from long-link mechanical technologies to integrated information and a shift in the function of labor because of this technological transition” (1986, p. 202). He and others further articulated the key differences in the nature of work between the industrial and postindustrial periods that undermined traditional STS design approaches (see table 2 for a summary of his discussion and visual representations comparing routine, linear work and nonroutine, nonlinear knowledge work).

As opposed to routine work such as manufacturing, in which the conversion processes were linear and the steps were reasonably predetermined, nonroutine work systems such as research and development (R and D) or market research involve a high level of equivocality in terms of their nonlinear conversion processes. Given this emerging reality, Pava cogently made this observation: “Altogether, these conditions invalidate key assumptions supporting conventional STS design: definable inputs and outputs, sequential flow of conversion, cascading one-way variances, and pooled group identity with transferable skills. Attempts to accommodate these conditions by rigidly adhering to the nine-step model and the autonomous work-group template ignore the major differences between linear and nonlinear work” (1986, p. 206).

Core Concepts of Pava's Approach

Pava responded to these challenges, and in so doing, he played a pivotal role in defining the second generation of STS thinking by extending it to the nonroutine work processes characteristic of knowledge work and the service economy. In Pava's view, the digital revolution presented such a challenge that neither the purely "soft" approaches of behavioral science nor the "hard" approach of industrial engineering could engender and sustain organizational learning and change as did the new unique approach of STS, which had already proven to "more effectively organize in the most uncertain steps of the conversion process and at the most problematic interfaces with a system's environment," which is the new context of work. The heart of the sociotechnical systems approach is the critical match between the technical and social subsystems in the performance of the work system as a whole. As the work shifted to knowledge work, it became more difficult to discern the elements of the technical and social subsystems because both related to people.

Table 4.2. Changing Nature of Work (Pava, 1986; Pasmore and Gurley, 1991)

	Routine Work	Nonroutine Work
Nature of work		
Context	• Stable environment	• Unstable environment
Nature of the technical system	• Long-link, mechanical processes	• Integrated information processes
	• Unitary, convergent, linear, sequential conversion process with a programmed series of steps	• Multiple concurrent, nonlinear, non-sequential conversion processes with poorly structured problems and un-programmed activities
	• Largely unvarying tasks with limited variety • Defined • One specified way	• Highly variable tasks with unclear inputs and outputs and too much variety • Undefined • Many potential ways
	• Sequential interdependence of subtasks	• Saturated, pooled or team interdependence
	• Repetitive, short cycle tasks	• Non-repetitive, long cycle tasks
Nature of the social system	• Work groups with shared identity	• Highly trained professionals with specialized expertise • Individualistic orientation
Nature of the governance system	• Hierarchical authority-based • Position-based authority • Clear shared goals	• Lateral, consensus-based • Expertise-based authority • Multiple, competitive goals
Variance analysis	• Obvious • Downstream with clear cause-effect relationships • Recognizable patterns	• Hidden • Multi-determined and multi-directional causal linkages • Largely un-patterned
Typical design options	• Autonomous work groups • Job enrichment • Multi-skilling	• Discretionary coalitions/role networks with explicitly defined responsibilities • Job simplification to reduce the equivocality of problems • Reticular organization with fluid distribution of information and authority

Sociotechnical Design Principles for Nonroutine Work Systems

To develop a sociotechnical design process for nonroutine office work, Pava revisited and reconfirmed the general theory of sociotechnical systems and its core tenets. Specifically, he stated that a work organization is an open system that meets these criteria:

- Interacts with a complex environment (transactional and contextual) and transforms inputs into outputs via a sequence of conversions.
- Benefits from an optimal match of the social and technical subsystems.
- Emphasizes redundant function over redundant parts.
- Can self-regulate many of its own activities through feedback (without excessive supervision because of shared goals).
- Must generate a level of variety that matches the level of flexibility required to achieve its purpose in its environment.

Furthermore, Pava reinforced the STS precept that the design process is as important as the design product and that it must be self-designing because only the participants in the "system" can determine its nature, purpose, and boundaries before designing its details. The participative design approach itself is a prototype of the managerial style required to realize the benefits of a sociotechnical systems design. The design process is based on *minimal critical specifications*, where only those things that must be defined are and is open ended because it must adapt the design as changing circumstances make the existing design obsolete.

Pava's approach focuses on *deliberations* as the unit of analysis for examining the nature of nonroutine work processes (Pava 1983; Taylor, Gustavson, and Carter 1986). The focus on deliberations implicitly expresses a core value of STS—that is, t*o advance the connections between the principles of democracy and the social and economic objectives of organizations.* The idea of deliberation is built on the notion of *participative governance*, where *reasons* and *inclusion* are the two central aspects that realize "just" or "legitimate" outcomes. The more a group of people exchanges reasons and foster an ethic of inclusion, the more likely the participants are to change their position, and thus the more likely a solution is to be derived based on collective intelligence and implemented with community consensus. Deliberation is a social, not a rational, process (Habermas 1990). The best articulation of deliberation is that by Fung and Wright (2003): "In deliberative decision making, participants listen to each other's positions and generate group choices after due consideration. Participants ought to persuade one another by offering reasons that others can accept. Real-world deliberations are often characterized by heated conflict, winners, and losers. The important feature of genuine deliberation is that participants find reasons that they can accept in collective actions, not necessarily ones they completely endorse or find maximally advantageous."

To analyze and redesign nonroutine office work and the interactions among people in the work system, Pava recommended mapping the sequence of *deliberations* that he defined as "reflective and communicative behaviors regarding a particular topic" (1983, p. 58). He further described deliberations as "equivocality reducing events" that are critical to nonroutine work systems, especially those involving knowledge generation and knowledge utilization. However, deliberations are not simply the equivalent of decisions or meetings; they are sense-making exchanges (Weick 1994), communications, and reflections that are integral to the nature of nonroutine work.

Rather than ignoring or minimizing the complexity of nonlinear conversion processes, deliberation analysis provided STS researchers and practitioners with a way to trace the sequence and type of deliberations in terms of the key *topics* or problematic issues to be addressed; the *forums* in which they occur; which ones may be structured, semistructured, or unstructured and ad hoc; the *participants with specific points of view*, both those who are currently involved and those who ideally should be involved in the deliberation; and *discretionary coalitions* whose purpose is to obtain the best outcomes from the inputs of multiple perspectives.

The deliberations or sense-making conversations often cut across formal departmental boundaries and involved informal patterns of exchange, which were specific to a topic. Thus, Pava coined the term for the social system, “discretionary coalitions,” which were flexible alliances of interdependent parties formed to make intelligent tradeoffs that enable attainment of overall objectives; different coalitions are associated with different deliberations. It was and is a novel organizing principle because it overlays or pushes the static positions of the organization chart into the background.

Unlike routine STS, the nonroutine approach emphasizes *reciprocal understanding* rather than a shared goal and *coalition formation* rather than group identity as one finds in self-managing teams that are permanent entities in the social system. Identifying major deliberations and the discretionary coalitions needed to manage them helps gain better alignment between the major lines of contention and the overall viability of an enterprise in a turbulent environment.

Deliberations are the key design element in the sociotechnical analysis of nonroutine knowledge work systems. *Deliberations* are patterns of exchange and communication in which people engage with themselves or others to reduce the equivocality of a problematic issue. Deliberations form a collectively built framework that creates clarity without denying complexity.

Also, when developed collaboratively, the *deliberation dialogical process* builds community and fosters more extended application and testing. Deliberations are not simply talking or giving opinions; reasons offer a justification for a stated position related to the topic under debate, an answer to the question, “Why do you say that?” Inclusion also means more than simple participation. Although talking is one part of including oneself in a group interaction, it is important that one’s contribution be on topic and purposeful and that one makes the effort to ask opinions of others or to reference previous points of view made by others in the group. Coalitions are network structures that are a different form of organizing than the traditional hierarchical forms.

STS Analysis of Nonlinear Knowledge Work Systems

The diagnostic steps of open sociotechnical systems design, according to Pava (1983, 1986) include analysis of the business, analysis of the technical subsystem, and analysis of the social subsystem.

Conducting an Initial Scan and Mapping the System

The purpose of an initial scan is to discern the mission or goals of the system and the governance processes and coordination mechanisms that enable or inhibit collaboration in pursuit of the mission. The mission and governance system provide the impetus for a self-regulating system of players who define and iteratively evolve the technical subsystem in terms of the key deliberations or issues they need to address to achieve the mission.

Technical Analysis

Pava (1983) described deliberations as choice points that are critical to work systems involving knowledge generation and knowledge utilization. From this general description, Purser (1990) defined deliberations in product development as “social interactions in which knowledge is exchanged to define or solve a problem, make a decision, or implement a solution.” A deliberation is identified by the existence of an equivocal topic that is explored in different types of forums, involving a particular group of participants who either contribute important information or take-away important information. Deliberation analysis assesses the values and perspectives of participants within forums, as well as “the interpretative dynamics among interdependent parties who must forge a discretionary coalition” (Pava 1983) to make intelligent tradeoffs from their respective values, priorities, and cognitive orientations (Tenkasi 1994, 2000).

Deliberations in knowledge work such as R and D can be viewed in terms of intellectual bandwidth (Nunamaker et al. 2001, 2002, Qureshi et al. 2002) and the ability to mobilize intellectual assets in deliberations to create value. The STS model of nonroutine work-system design provides a framework for measuring the extent to which an organization can create value from its intellectual assets by looking at two key elements in deliberations. The first is the process of understanding the data and available information and translating it into knowledge. The second addresses the interdependence of efforts and whether it is primarily an individual work mode, a collected work mode and the sum of individual work, a coordinated work mode in which there is sequential interdependence, or a concerted work mode in which everyone works in concert to produce joint deliverables.

Social Analysis

The social system is defined in terms of discretionary coalitions that are needed to conduct the deliberations effectively. These coalitions make the important tradeoffs in creative work that is made necessary by the presence of useful but inherently divergent values and perspectives. For example, in traditional research environments, scientists typically compete against one another for limited grant money and to publish articles in top journals, neither of which enable the effective functioning of coalitions in a virtual project. The social-system design does not try to eliminate differences, but rather tries to create a mutual understanding and a common orientation so that tradeoffs can be settled on an intelligent and ongoing basis. Coalitions are to nonroutine work what work groups or teams are to more routine work. Roles and responsibilities can be defined for the parties involved in the coalitions, as well as other changes in the coordinating mechanisms in a way that supports and rewards the sort of integrative perspective necessary to successful coalition functioning.

From Variances to Knowledge Barriers and Dynamic Synchronization

In traditional Tavistock-North American sociotechnical systems analysis, the focus is on addressing and eliminating variances in work processes and performance. However, in nonroutine knowledge-work systems, Ron Purser and colleagues discovered that variances manifest as knowledge barriers—that is, any factor that inhibits or undermines building the pool of shared knowledge and new insights in timely fashion. Purser (1990) conducted an in-depth STS analysis of a nonroutine work system—the research and development function of a major corporation. He used quantitative methods such as surveys and qualitative methods such as observations to analyze key deliberations and discover critical variances that contributed to delays on research projects. Purser discovered that delays occurred when there was a lack of critical knowledge or information to make decisions, when there was inadequate time to make thoughtful decisions, and when information was missing due to poor documentation of previous projects. All of these variances were, in fact, knowledge barriers. Purser, Pasmore, and Tenkasi (1992) subsequently used factor analysis to identify four main categories of "barriers" obstructing and delaying collaborative knowledge development: lack of a common frame of reference, failure to share knowledge, lack of knowledge, and failure to use knowledge. Let's look at each category of barriers more closely.

The *lack of a common frame of reference* includes cognitive frame-of-reference barriers typically associated with differences in expertise, values, cultural norms at both the corporate and national or ethnic levels, and language. This barrier is most likely to occur when the discretionary coalitions span company, sector, and national and cultural boundaries. One of the most often overlooked yet critical design activities is to establish a common lexicon or shared language.

1. The lack of a common frame of reference contributes to the second knowledge barrier: *failure to share knowledge*. Failure to share knowledge occurs when key participants are not included in the deliberation or when the participants in the deliberation are unwilling to cooperate. In highly competitive organizational cultures with "knowledge is power" norms, participants may be reluctant to share what they know. Similarly, when there are conflicts or distrust between groups or among individuals, relevant information is often withheld. This knowledge barrier is often exacerbated when there are unrealistic time frames and other time pressures that serve to narrow a person's focus to his or her immediate task at the expense of sharing knowledge that might benefit other participants in the deliberation.
2. The third knowledge barrier is *lack of knowledge* about the work, the procedures and processes, or capabilities that can slow or derail progress regarding deliberation topic(s).
3. In the case of the fourth knowledge barrier, the failure to use knowledge, the knowledge for completing the task, deliberating, and making decisions exists but is either ignored or used improperly.

Purser and colleagues (1992) determined that these knowledge-management barriers were due to poorly designed and mismanaged deliberations. To improve deliberation efficacy and ensure that relevant parties are involved in key deliberations and that they have a common lexicon, and adequate time, Purser and colleagues offered the following recommendations:

1. Align the most useful skills of participants with the various deliberations.
2. Ensure that reward systems foster knowledge sharing.
3. Implement a participative learning system.
4. Allocate sufficient time for learning in the early stages of product development.
5. Design deliberations that promote knowledge development and learning.

Pasmore (1994) confirmed Pava's earlier work that the differences between variances in routine and nonroutine work are so significant that they require new STS thinking—more specifically, that adequate preparation and problem definition are critical so that people can organize themselves to deliberate effectively on the questions they have identified. He also further elaborated the characteristics of effective and ineffective deliberations. See table 4.3 below.

Table 4.3. Characteristics of Effective and Ineffective Deliberations (Pasmore, 1994)

Effective Deliberations	Ineffective Deliberations
• Knowledge highly developed and readily available • Knowledge utilized fully and without bias • Apolitical discussion of facts and alternatives • People with most knowledge present • Disruptive or inappropriate people absent • Discussion held at key choice points • Goals clear and shared • Challenging but realistic time frames • Decision-making procedures clear • Appropriate attention to external environment • Minimum bureaucracy	• Lack of knowledge • Failure to use knowledge • Lack of cooperation • Missing parties in key discussions • Wrong parties in key discussions • No key discussions at all • Lack of goal clarity • Time frame too short or too long • Procedures unclear or non-existent • Inadequate attention to external environment • Too much bureaucratic structure

Adler and Docherty (1998) extend this shift in thinking regarding variances in knowledge work from minimizing them to seeking "dynamic synchronization." This is a concept Purser and Pasmore (1992) introduced that is based on maintaining a balance between order and disorder. Order affords the systemic coherence needed for the technical and social subsystems to achieve task requirements, while disorder can actually be beneficial to the extent that ambiguity and uncertainty trigger opportunities for creative learning. For example, serendipitous findings that are typically outliers or unexpected results—and would be considered variances in routine work systems—are often critical in creating scientific breakthroughs.

4.3 Illustrative Examples of Nonlinear STS in Practice

Pava provided the most illustrative cases of the application of deliberation analysis: the software engineering group in a moderate-sized computer systems firm (1983) and the customer service and support unit in a rapidly growing microcomputer device company (1986). In the case of the microcomputer device company, management had decided to install a new computer system. However, they were not convinced that the recommended system requirements would achieve the desired levels of customer support. An STS design effort was initiated, and business, technical, and social analyses were conducted. The design team proposed that the customer support unit be reorganized into market team structure. Six regional support teams were established to provide full line service and to acquire customer and market data for their region. There was a modest amount of cross-training and a moderate degree of job enrichment, along with a pay-for-skill ladder. All would be shared with the team first. At the end of the first year, customer satisfaction had improved significantly, and the teams had achieved unexpectedly high scores on the performance measures they had jointly established during the redesign.

While other STS practitioners have employed elements of Pava's nonroutine STS design in their work, there have been few documented cases of the formal application of deliberation analysis and redesign. There have, however, been several qualitative research studies that have focused on the conditions that contribute to deliberation efficacy. Most recently, the Sociotechnical Systems Roundtable, in collaboration with the University of Illinois, received a grant from the National Science Foundation to study deliberation efficacy in three virtual research projects: the Orchid Project, which is a collaborative project among physicists from research universities around the world and basic research on the R-and-D continuum; the Uniform Data Set Project (UDS), which is a joint project among twenty-nine Alzheimer's Disease Centers across the United States and began at the advanced development stage; and a Large Video Game Project, which involved some startup, but mostly scale-up development activities such as art-asset production, engineering, and testing activities shared among the game developers and vendors around the world (Barrett, Austrom, Merck, Painter, Posey, and Tenkasi 2013).

Barrett and colleagues focused on understanding the influence of virtuality on deliberations and knowledge-development barriers at various stages of the R-and-D continuum. This comparative study of virtual, geographically dispersed RD projects reinforced the importance of understanding and managing the challenge of coordinating work and knowledge across time and space. Building on the theory of organizations as information-processing and knowledge-utilization systems, the research identified different types of coordinating mechanisms and their effect on managing knowledge-development barriers across the R and D spectrum.

4.4 The Legacy of Pava's Approach to Designing Nonroutine Work Systems

Pava had the foresight in 1983 to see extensive network organizing in the future that was a natural fit with sociotechnical systems thinking, built on a foundation of self-regulation to deal with the complexities and uncertainties emanating from an increasingly turbulent environment (Emery and Trist, 1965). He called to our attention a new kind of knowledge work that went beyond a focus simply on decision-making to a wide range of cognitive methods and techniques that managers and professionals use to resolve complex issues that are the essence of their work. Finally, he also warned us that increasing computerization could result in a technocratic imperative and thereby erode our ability to generate what Bright and Fry (2013) called "humane, high-performing, and ethical organizing."

Pava provided us with a template for a truly *holistic organizational architecture* based on the precepts of self-regulation. Trist (1983) stated in the afterword in Pava's book that the concept of self-regulation was meant to be extended to every control level so that the organization as a whole was seen as a series of mutually articulated self-regulating systems, which would make it both flatter and leaner. He articulated three types of work and organizing forms for this *holistic organizational architecture*, as follows:

- **Routine work**—Primary task work becoming digitized and regulated by *self-managing teams*
- **Hybrid (routine and nonroutine) work—***Project teams* (for innovation, change, and research work, as has been more traditionally used, as well as for realizing customer orders in project-based companies and in those companies in which the primary task is done at exceptional speed requiring very agile coordination)

- **Nonroutine work—**Deliberations and *discretionary coalitions* that describe the interactive character of a great deal of day-to-day work of managerial, professional, and even primary task groups in which work is based on high uncertainty and complexity.

In so doing, Pava combined and integrated self-managing work teams (routine), project teams (hybrid), and discretionary coalitions (nonroutine) into a *reticular organization* (network/ecosystem) with participants jointly creating value and their future. And in our iVUCA (interconnected, volatile, uncertain,complex and ambiguous) postindustrial era, this is critical to the survival of the enterprise because as Peter Drucker argued in 1966, everyone must be a contributor: "Every knowledge worker in a modern organization is an 'executive' if, by virtue of his position or knowledge, he is responsible for a contribution that materially affects the capacity of the organization to perform and to obtain results."

While most people instinctively knew there was a difference between routine and nonroutine work, few were able to describe its core content as cogently, and those who tried put too much focus on decision making to the exclusion of a whole range of cognitive activities that occur in the unprogrammed work of professionals and managers. But as robust as this approach to designing contemporary work systems has been, Pava's warnings about complacency in STS design appear to have gone largely unheeded. There are several factors that may account for this outcome, not the least of which was the failure of STS design to keep pace with changes in the fundamental nature of work and work systems. As Pava argued, it may have been due to an overreliance on traditional methods. Also, the paucity of documented cases using STS design for nonroutine work systems attests to the fact that we have not generated pragmatic methods with tangible steps that others can follow. As Pava observed, "Without grounded concepts and usable methods, the aspirations of STS design become an unfeasible litany" (1986, 209).

The variegation of the field with numerous derivative or related methodologies has also been a factor, to the point where STS design in North America has effectively been supplanted by other methodologies that share STS values and principles to a greater or lesser degree. Examples include appreciative inquiry (Cooperrider 1990), democratic dialogue (Gustavsen 1992), Lean thinking, Ackoff's democratic hierarchy (1999), and more recently, sociocracy (Endenburg 1998) and holacracy.

Conclusions

Pava's STS shows us how to design a *dynamic emergent organization*, which is a much better fit with today's iVUCA environment. Further, he claimed it is the only way to design "healthy organizations" in today's technologically driven workplaces because it goes to the heart of the structural and cultural issues that must be designed to achieve both humane and high-performance workplaces.

Pava warned us about what he foresaw as a relentless technology drive that, if left unchecked, would result in a*rtificial rationality* that is characterized by the belief that human shortcomings can be "engineered out" with technology and rational methods. He also warned us about *micromyopia*, which "seeks analytically to rationalize nonlinear work into discrete components to increase the efficiency of parts based on the belief that this will increase the efficiency of the whole set of work activities" (Pava 1983, 53). What Pava could not fully envision was the scope, scale, and pace of the digital revolution, especially the advent of smart devices and how pervasive "bring your own device" would become in the early twenty-first century. These and numerous other technological innovations comprise the burgeoning field of information and communication technology (ICT). But except for a few notable exceptions (cf. Mumford, 1995), relatively little work has been done on deepening our understanding of the relationship between ICT and sociotechnical systems in the analysis and design of contemporary work systems. This is clearly an area of inquiry that warrants considerable attention.

Finally, nonroutine work and work systems today are more complex than ever. To respond to these dramatic changes, organizations have had to "learn and change" in ways that have been far more profound than the traditional methods such as training and procedural enhancements. A new paradigm for managing and leading was, and is, needed. But Pava did not directly address this. In a later chapter, we discuss how STS first principles provide us with a new paradigm that becomes the foundation for network design and organization.

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